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John M. Diven

A Tribute

With profound sorrow we have learned of the passing away on January 4 of our fellow officer in this Association, which he helped establish, John M. Diven, Secretary Emeritus.

His whole long career was devoted to water supply. It began when he was twenty years old, in 1872, when he became secretary and treasurer of the private water company at Elmira, N. Y. At its close he was still engaged, after fifty-two years of active participation in water works affairs, in this work so close to his heart that to him it was rather a pleasure than a task.

In this long and useful career he was connected with the water works of Elmira, of Charleston, S. C., and of Troy, N. Y. The success of his management in each place is widely known. He was long recognized as a leader among the men in charge of water works operation. Possibly it is not so well known that he repeatedly demonstrated unusual ability as a construction engineer, and he would probably have become an engineer in early manhood had he not had an even stronger liking for the operating side of water works affairs.

His name will be well known in water works circles long after we too have trod the way he took on January 4. The American Water Works Association was his joy, his pride. He cherished it in its days of adversity, when it would have been snuffed out but for his self-sacrificing care. He fought, on many occasions, a good fight to keep it a water works man's association, and always won because he was right. That the Association is today so successfully serving the water works of the United States and Canada is largely the result of his many years of devotion to its upbuilding. It must be the Association's duty (as it will be its pleasure) to devise some appropriate means by which the Association's indebtedness to him shall be perennially recalled.

FRANK C. JORDAN,
GEORGE W. FULLER,
W. S. CRAMER
WILLIAM W. BRUSH,
CHARLES R. BETTES,
Administrative Committee.

January 8, 1925.

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OF THE

AMERICAN WATER WORKS ASSOCIATION

The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings
Discussion of all papers is invited

VOL. 13 FEBRUARY, 1925 No. 2

CONTROL OF APPROPRIATIONS OF WATER IN CALIFORNIA[1]

BY EDWARD HYATT, JR.[2]

INTRODUCTION

The Division of Water Rights is that branch of the state government which has charge of the administration of the state's water resources. The office was formerly known as the State Water Commission. The Water Commission Act creating the State Water Commission was passed by the legislature in 1913, but was withheld by referendum and was approved by a majority vote of the people at the general election in November, 1914, and became effective immediately. The office was established in San Francisco and remained there until 1922, when it was moved to Sacramento. In the meantime the law had been amended in 1921, making the State Water Commission one division of the State Department of Public Works, namely, the Division of Water Rights. The other Divisions of the Department of Public Works are Engineering and Irrigation, and Architecture. Mr. A. E. Chandler was President of the State Water Commission during the first four years of its existence. He was succeeded by Captain Charles H. Lee and, on the removal of the office to Sacramento and the resignation of Mr. Lee, Mr. H. A.

[1] Presented before the California Section meeting, October 24, 1924.

[2] Chief of Division of Water Rights, State Department of Public Works, Sacramento, Calif.

Kluegel was appointed Chief of the Division. Major Kluegel resigned several months ago and the speaker is now at the head of this office.

A description of the functioning of the Division of Water Rights will, I believe, be of interest to the members of the American Water Works Association, since questions of sufficiency of water supply and water right titles enter into nearly every development involving use of water.

The subject of water rights in California is, as probably most of you are aware, exceedingly complicated and with a bar sinister in the nature of a long and grievous history. In the following paper I shall try to cover, first, a summary of the functioning and general activities of the Division on water matters in the state at large, and, second, a closer description of recent developments and the present situation in the Sacramento Valley and its possible effect upon the Sacramento City municipal supply. The present critical season has had some very interesting aspects, both physical and economic, and I hope later on to be able to present some of them to you.

SUMMARY—FUNCTIONING OF OFFICE

To explain the position occupied by the Division of Water Rights and its duties and jurisdiction and lack of jurisdiction it will be necessary briefly to review the situation historically and legally.

History

California water history and water troubles go back to the days of the Forty-niners. During those early days, both before and after California became a State in 1850, there was practically no law regarding either water rights or mining rights on the public land. The miners were trespassers against the United States in going upon public land at all, and there grew up a "possessory" system of mining rights under which the rule of first come, first serve was observed. A miner staked out a claim and posted a notice of it, and as long as he kept actual possession his title as against everyone but the Government was recognized. In an exactly similar manner water rights grew up. Water being necessary to work the mines, the miners simply took or appropriated such water as they needed and posted a notice of their appropriation to protect their use of the water. This was the beginning of the

appropriation doctrine which is in use throughout the Western United States today.

The Federal Government in 1866 established the rights of the miners upon the public domain both as to land and water, and the theory of appropriation of water was recognized both by State and Federal courts.

However, California in her constitution had inherited the riparian right doctrine from the common law of England and almost from the first the difficulty, or rather impossibility, of reconciling the two theories was apparent.

The riparian principle is that the right to the water in a stream is vested entirely in the abutting landowners; that the right is not created by use and does not cease with disuse. It originated in England, a land of humid climate where irrigation was unknown, where there were no rights in a stream or use of its waters other than by the landowners along the banks. It is practically universally admitted that the theory of riparian rights is entirely unsuited to an arid region or one where the lands require irrigation. Thus it is seen that the two classes of water rights trace their origin to entirely different sources and are absolutely conflicting both in theory and practice. After a great deal of litigation the issue between them was squarely joined in the famous case of Lux vs. Haggin, which was decided in 1886, in which decision by a four to three majority the riparian right was held to be a right of property protected under constitutional principles and superior to appropriative claims. By this decision riparian rights were definitely recognized and the riparian doctrine definitely fastened upon the State.

The situation from the earliest was such as to give rise to a great amount of litigation. The principles of appropriation were very poorly defined, there being only a very few short sections in the Civil Code concerning them, and riparian rights were nowhere mentioned in any statute or law, being covered only by reference through the constitution. Confusion and misunderstanding inevitably arose in the application of opposing principles so ill-defined, and there being no adequate law on the subject disputes could be settled only in court. The history of California water development has been since 1850 one of conflict and lawsuits, there having been about 500 water cases which have reached the Supreme Court of the State. Many of these were among the longest and most bitterly

fought cases on record, the Lux-Haggin decision in 1886 being the longest ever written by a California court.

Thus there grew up, through the hundreds of Supreme Court decisions, a system of court law regarding water rights, which was, however, incomplete as to points not passed on, conflicting as between decisions, and impossible because of complexity and length for the layman or even the average attorney to master. Without doubt, California, where irrigation was so important, had the poorest water laws of any state in the Union. Many other irrigation states refused from the beginning to recognize riparian rights, probably as a direct result of California's troubles, and in the non-irrigating states the appropriation doctrine was unnecessary.

Attempts were made to remedy the situation by following the example of the other Western States, where complete water codes were in successful operation. Many of these Western states were more arid than California and possessed of no considerable underground supply and were utterly dependent upon irrigation for any considerable crop production and were by necessity forced from a very early date to meet their water problems with adequate machinery for solution. In California there was determined opposition to any change, however, by the holders of vested water rights, particularly by riparian owners, and the movement for a water code was unsuccessful until 1913, when due to the efforts of several earlier boards and commissions the present Water Commission Act was passed.

The Act provided a Code for the orderly administration by the State of its remaining water resources, for adjudication of rights already in existence, for the distribution of water by water master to water right owners, and for stream system investigations. Due to the conditions described the statute was necessarily long and complicated. The basic principles as established by court decisions through sixty years could not be more than modified, established rights could not be endangered, and unused riparian rights being more or less property rights were a doubtful subject of legislation. The Water Commission Act probably went as far as possible by legislation to establish a complete and efficient code. *However, the simple fact was that a direct and efficacious solution was not possible at this late date in California, as it had been earlier in other Western States.*

The State Water Commission therefore faced a situation fraught

with unusual dangers. Its jurisdiction was limited by constitutional inhibition and by court decrees. Therefore, for the first few years especially it was necessary for the Commission to move slowly and to feel its way through the maze of legal entanglements and to establish precedent for handling the water problems of the State in an orderly manner.

You will note that I do not state that the Water Commission and Division of Water Rights have solved the water problems of the State of California. They have not. They have gone a great way in that direction and the background of legal history which I have just related explains why the state office has been unable to take firmer control in the direction of water development. The solution of the problem has however been proven in California as in nearly all the Western States. It is by a Water Code such as the Water Commission Act which allows the orderly initiation and recoördination of new rights, the ascertainment of existing rights and the distribution of water by water master, all accomplished by a proper coördination of hydraulic engineering and court procedure. Though our problem is one of unusual difficulty the plan to solution adopted has been tried and proven elsewhere, it is in the course of consummation in California today, and in the end it will triumph. Though it is perhaps not perfect in detail, it is the only method ever known to have achieved the satisfactory result and is the method which must be pursued. This procedure has been adopted and has resulted in wide-spread development in Wyoming, Idaho, Colorado, New Mexico, Arizona, Washington, Oregon and Nevada.

Applications to appropriate water

Prior to the adoption of the Water Commission Act in 1913 appropriative rights could be initiated under the Civil Code by posting a notice of appropriation at the point of diversion and recording a copy of the notice with the County Recorder and proceeding to construct the necessary works; or a right might be acquired by merely constructing the necessary works and applying the water to beneficial use.

Under this system there was no attempt to define the project for which the appropriation was made. The amounts claimed were usually out of all proportion to what would be required for reasonable use—notices specifying millions of miner's inches were not uncommon—on most streams in the State the amounts for which

notices are recorded many times exceed the extreme maximum flow of the stream. It was possible to maintain a color of right by simply posting a notice once every sixty days, so that naturally in a short time the County Recorders' records were valueless for the purposes of information regarding actual water rights.

Under the Water Commission Act it is necessary to file an application with the Division of Water Rights to initiate an appropriative right. Before an application can be approved the applicant must submit maps and data giving the source of the appropriation, the location of the point of diversion, the capacity of the diversion works, the location and character of the use, and all other facts necessary to described adequately the project. If an application is protested the protest is thoroughly investigated by means of a hearing or a field investigation, or if necessary both, and it is not approved unless it appears that there is unappropriated water available in sufficient amount to justify a permit. Permits are not issued for water in excess of an amount consistent with the beneficial use on the project contemplated, and in a permit dates for beginning and completion of construction and for completion of use of the water are set.

By means of annual progress reports the Division checks up on the progress of the work. Those on which diligence has not been shown are revoked and the water becomes again unappropriated. Extensions are allowed on those on which diligence is being maintained and on which further time is required, and when a project is completed it is inspected by an engineer from the State office and a final water right, or license, is issued in conformity with the project works built by the applicant and the amount of water actually applied to beneficial use.

Under this procedure a very clear record is kept of all water rights initiated within the State. The files of the Division of Water Rights now contain a complete list of all appropriative rights to the use of water initiated since the approval of the Water Commission Act, and reference to a single map shows not only the location of each diversion point, but the status of the right, as to whether it is only initiated, approved for permit, or confirmed for license, and also the character of the use, whether agriculture, power, municipal or mining.

Through the data which all filed by the applicant in completing his application for permit and completing the use of water under

the permit a very clear definition is obtained for each right initiated; also, through the close investigation of all protested applications the extent of interference of the proposed diversion with vested rights is established and the chances of conflict or litigation are minimized. More than 4200 applications to appropriate water have been filed with the State Water Commission and Division of Water Rights, and 1800 permits have been issued, and 1500 applications rejected. Only about a half dozen of these decisions have been appealed to the courts and so far not one has been reversed by the courts.

A very valuable function is performed by the Division of Water Rights by the elimination of applications and permits which for any reason do not result in actual construction work and use of water. This is largely brought about by clearing out speculative and visionary projects and by scaling down to reasonable amounts the quantities applied for.

The completion of an application with proper accompanying maps and definite statement of plan and the working out of protests is no hardship on the bona fide project. Every step required by the Division is one which the manager of a project must in any event take for its orderly development. But the surveys, the preparation of maps, the response to protestants, throws a burden upon the visionary, speculative and impractical projects which results in the lapse of their rights and prevents them from standing indefinitely in the way of live projects.

Activity in development of water projects as shown by applications before the Division of Water Rights is continuously on the increase. At the last legislature the law was amended to provide for a graduated fee schedule in connection with applications, a dollar a second foot up to 500 second feet, etc. This fee schedule has undoubtedly prevented the filing of a large number of applications which otherwise would have been made. However, in spite of this the number received during the last year was as great as the year before and during the present summer applications are coming in at the greatest rate ever known. A number of reasons contribute to an ever increasing demand upon the remaining water resources of the State. The present dry year is a potent immediate reason, but is underlain by more important economic facts. The increasing prosperity of the state, coupled with the fact that further agricultural and power development is limited by the water available, has tremendously accelerated the demand. The operation of the Water Commission

Act, which provides that riparian rights not used by 1924 will lapse, has also had its effect. These various reasons combine to produce the increased rate of receipt of applications during the present year.

Applications are segregated by use into agriculture, power, municipal and mining, all industrial and miscellaneous uses coming under agriculture. The gigantic developments being made in this State along the lines of agricultural and power projects are so well known that I will not attempt to enumerate them here. Practically all of them however are before the office of the Division of Water Rights for approval several months or years before construction begins. The ordinary procedure is to secure the water rights at the same time that the organization work is being done on the irrigation district or power company, then finance the project and then construct.

I might take time to note, however, the trend of municipal water supply projects. There are pending before the Division of Water Rights at the present time a number of applications for water for municipal purposes for various cities in the State, exclusive of Sacramento, which will be taken up later on. The most important ones are:

The City of Los Angeles has recently applied for 1500 second feet from the Colorado River. This would necessitate a conduit about 250 miles long and 60 miles of tunnels, pumping water against a head of 1400 feet at one point, and an estimated expense of $150,000,000 or more, these figures being all very approximate.

The East Bay Municipal Utility District, including Oakland, Alameda, Berkeley, and smaller cities, very recently filed on the Mokelumne River for municipal purposes. They plan to build two very large storage reservoirs. The total cost of the project is estimated to be $64,000,000. The East Bay District will submit to the electors in November a bond issue for this project.

The City of Pasadena has filed an application to store water on the San Gabriel River and transport it from there to Pasadena for municipal use.

Stockton has applications on file on the Calaveras River for municipal and flood control purposes.

An application is on file for a storage reservoir near San Diego for municipal use in that city.

Napa has just completed a considerable project. Vallejo is just starting one, and a number of other smaller cities also have plans for municipal water supply projects from surface stream sources.

Determination of existing water rights

As already explained, since the Water Commission Act went into effect in 1914 appropriative water rights can be acquired only under its provisions, and, since that time, all such rights are clearly defined.

However, most of the present irrigated acreage in the State acquired its rights prior to the Water Commission Act, and the loose methods of filing then existing and the lack of supervision to determine whether all or any part of such rights have become vested by use has resulted in the existence of a vast number of rights undefined and in a great many cases even unrecorded. After the waters of a stream are all taken up or when a subnormal year occurs, such a state of undefined rights inevitably leads to conflict and litigation. The solution of this difficulty is in the adjudication or determination of all water rights on the stream system. Prior to the Water Commission Act this was all left to the courts. Judges with insufficient evidence before them were required to adjudicate rights as best they could, and it is not to their discredit that they often decreed far more water than the source could supply. Nor is it to their discredit that so handicapped by lack of facts they could not satisfactorily settle water disputes. Court machinery for fact finding—the testimony of witnesses according to rules of evidence—is efficacious in ordinary cases, but not so in water cases. Legal questions in connection with water litigation are easier of solution if they can be approached free from the confusion of details of conflicting evidence as to fact. The facts as to water supply, areas irrigated, ditch capacities, and similar matters can be more accurately determined in the field than elsewhere.

Water is probably the most difficult subject matter of all litigation, as it is by nature so variant in quantity and so elusive in character that only highly trained and impartial experts working over a considerable period of time and recording data can compile and submit to a court true facts of the case, and then only can a court intelligently proceed to finally apply the law.

All of which is preliminary to explaining the functions of the Division of Water Rights in adjudication or determination of water rights.

The Water Commission Act provides a complete procedure for the adjudication of water rights by stream systems and further provides that when the report of the office is complete it shall be

submitted to the Superior Court of the county in which the lands lie; that the court shall, after making any necessary changes or modifications, render a decree adjudicating the water rights between the various claimants. By this method the Division of Water Rights does not itself finally determine the water rights—if it did this would be a judicial function and unconstitutional. However, the Division collects the records, makes the surveys, compiles all the date, and submits a complete report to the court and the court has the advantage of a complete, accurate and impartial set-up of the facts in making its decision. About a dozen stream system areas have been adjudicated or determined by the office in this manner, and in those which have been completed the court has in all cases adopted the report of the Division with but very slight modification.

When the rights on a stream are established and known, as by an adjudication, it then becomes possible to distribute the water in accordance with these established rights; that is, it is possible for a water master to go upon the stream and take charge of it. Under the Water Commission Act this water master is a state official and to interfere with his actions or tamper with headgates he has set is a misdemeanor. When this stage is reached the question of proper utilization of water on a given stream is practically solved. It has been long ago demonstrated in every other Western State that this method means complete success, and is the only method which can bring success.

Adjudication work throughout the state is proceeding with greater rapidity each year. The costs of this work are defrayed immediately from a state fund, but are later assessed back against the lands benefitting and the fees used to reimburse the fund, which has been found to be the most satisfactory way of financing this work. Due mainly to the present subnormal season there has been a great demand for water master service, particularly in the northern part of the state. Upon some streams which were not adjudicated or were in the process of adjudication, under the stress of an imminent shortage of water it was possible for the users to reach a temporary agreement under which a water master could operate.

Another function of the Division of Water Rights is the hydrographic investigation of stream systems. On many streams the physical facts regarding the amount of water available and the use that is made of it are unknown to such a degree that it is im-

possible for the Division of Water Rights to base intelligent action thereon or for existing communities to plan further development. The necessary facts can be developed only by a thorough hydrographic investigation.

A considerable demand exists for the direction by a disinterested agency of such investigations in various parts of the State. The determination of obscure physical facts must be made by experienced and competent engineers; also, the results to be of full value and acceptable to local interests must be entirely impartial. The Division of Water Rights as an impartial fact finding body with specialized experience along these lines is singularly well-fitted to render this assistance, and has done so on a number of occasions. Underground water problems which are unusually baffling occur mainly in Southern California. The Division concluded sometime back an investigation of the San Jacinto Basin in Southern California and is at the present time engaged in an even more comprehensive study of the San Gabriel River Basin. It is estimated that this work will take two years and cost some $40,000. The Sacramento-San Joaquin River system is at present under investigation.

In all of these studies the expense is met nearly entirely by the applicants or parties otherwise interested, the state supplying but a very minor part.

It will therefore be seen that California's water code is complete as to appropriative water rights. The procedure for the initiation of new rights, for the adjudication of old rights, and for the distribution of water to all existing rights is complete, and the problems created before the adoption of the Water Commission Act could be gradually and surely worked out were it not for the riparian right situation. Returning to this for a moment, Section 11 of the Water Commission Act provides that riparian rights not exercised for a period of ten years after the final passage of the Act in 1914 will lapse. This law will very shortly become effective. If we were able to say definitely that it will be upheld by the courts the solution of our worst water troubles would be in sight. However, legal opinion is divided as to whether or not this law will be upheld. Some of the best qualified attorneys in the State say the United States Supreme Court will in no case allow such a law, even if the State Supreme Court should, others that the United States Court will uphold the State Court in whatever it decides in this case. All we can do in this matter is to wait and hope for the best.

In this connection, the basic theory upon which riparian rights are defended today is upon the grounds that they are vested rights. A great injustice will be done to holders of vested rights and to the tremendous investments which have been built up upon them if any encroachment is allowed. The figures of the last United States census are interesting in this matter. According to the census there were 4,219,000 acres irrigated in California in 1920. The total acreage irrigated is classified in the census by the character of water rights under which water was received. The segregation is as follows:

	acres
1. Notice filed or appropriation and use	1,183,969
2. Adjudicated by court	982,157
3. Permit or License from state	105,968
4. Underground	863,613
5. Riparian rights	240,512
6. Other and mixed	396,703
7. Not reported	446,118
Total	4,219,040

In this segregation, some riparian acreage is undoubtedly included in the classifications "Adjudicated by court," "Other and mixed," and in the "Not reported," however with only 240,000 acres reported as riparian it is probable that at the most not more than about 700,000 acres received water under riparian rights and that about 3,500,000 acres received water under other rights. Therefore, not more than one sixth of the present irrigated land in the State receives its water under riparian rights. Five sixths does not. It is therefore apparent that the vested rights of California in the matter of water development are actually not under riparian rights to a large extent—not over one sixth. It would seem that the courts should give due consideration to this condition.

In connection with the values involved the total value of the crops produced from the 4,000,000 acres was about $300,000,000, and from other figures in the census table it was found that the value of irrigated land in California was in 1920 $1,400,000,000, or about $335 per acre. Unirrigated lands were worth less than one sixth as much, or about $55 per acre.

While no figures are available as to segregation under different classes of water rights of other uses made of water, such as power, municipal and mining, it is our belief that still less will be found

under riparian rights in these uses. The great power developments of the State are nearly entirely under appropriative rights, municipal entirely so, and mining entirely so, so far as is known. It is my my belief that, if the figures on the other uses were available, it could be shown that the tremendous investment and values in this State created by water development are based on riparian rights to a considerably less degree than one sixth or 16 per cent as estimated for agriculture alone.

SACRAMENTO RIVER SITUATION

Recent history

By the United States census figures there were 10,900 acres irrigated from the Sacramento River direct in 1902 above Sacramento, and 194,000 acres in 1919; that is, about 18 times as much land was irrigated in 1919 as in 1902 from the Sacramento River direct.

The majority of the development in the Valley has come about since 1910, and mainly since the Water Commission Act became effective, so that nearly all of the larger water rights from the river have been secured through permit from the State Water Commission or Division of Water Rights, making our records unusually complete as regards the Sacramento Valley.

The great increase in irrigation is due to a considerable extent to the establishment of the rice industry. As will be shown by a diagram later on, there was practically no acreage of rice in 1912. In 1920 over 150,000 acres of rice were harvested. This decreased to slightly over 100,000 in 1923. While it is true that during the period 1917 to 1920, when the price received for rice was very high, much land was devoted to rice culture which was not best suited for rice and will probably not be used for rice in the future, the rice industry in the Sacramento Valley is now on a stable basis and there is no reason to assume that the acreage will decrease further materially. Rice is particularly well adapted to the heavy soils of the trough areas on each side of the River proper. On these soils rice can be raised with the minimum amount of water as the seepage is very slight; also, the value of these lands for other crops is small. It is estimated that there are possibly 200,000 acres in the Valley which may continue to grow rice indefinitely.

The irrigation of other crops in the Sacramento Valley will cer-

tainly increase if the water can be secured. The census figures just quoted and the figures on water applications from the Division of Water Rights show that irrigation in the Sacramento Valley is increasing at a great rate. New projects are constantly being considered, and started as fast as they can be proved economically feasible. An entirely new 13,000 acre project near Dixon, about 20 miles west of Sacramento, is said to be about to begin construction. The well known Iron Canyon project is being re-studied on an alternate plan with better possibilities of success than before. This project provides for a storage reservoir of over 700,000 acre feet capacity above Red Bluff and the irrigation of 200,000 acres or more of land on the west side of the Valley. A large project is being actively promoted in the neighborhood of Chico. A great many applications are being received by the Division for smaller projects or individual developments.

The irrigable area in the floor of the Sacramento Valley is 2,700,000 aces besides the foothill lands, which will some day need water. Considering that by the Census there are only about 300,000 acres irrigated at the present time it is seen that irrigation development will not be stopped by lack of suitable agricultural lands in the Sacramento Valley.

From the figures quoted it is apparent that irrigation development in the Sacramento Valley is going on at a rapid rate and that it will continue, provided the water is available. If storage has to be resorted to and it cannot be economically secured this will tend to slow down such projects. But it is clear that development from the natural flow will proceed until no more water is available, if in fact that condition has not been already reached.

The Sacramento River is an excellent stream for irrigation in that it has a relatively large summer flow. This is due to the fact that many of its largest tributaries originate in springs issuing from the lava beds in Northeastern California. The flow of these springs is practically constant regardless of the time of year or the rainfall of that particular year. The largest of these streams coming entirely from springs is Fall River which has a uniform flow of around 1400 second feet. In an ordinary year this may go down to about 1000 second feet in the fall and, in 1924, a long series of subnormal rainfall seasons has culminated in the driest year of record, and this year it is understood that Fall River has gone as low as 900 second feet. One interesting item regarding Fall River is that the run-off is

considerably more than that which would be supplied by the entire rainfall on the watershed, and it is believed that the springs are supplied from the underground waters underlying the lava beds to the East. The normal low flow of the Sacramento River during irrigation months is about 4500 second feet measured at Red Bluff, which is the accepted point of measurement in this connection. In 1924 the lowest flow at this point was 2800 second feet, which constitutes the irrigation supply for the valley and the Delta regions below, since in a dry year the tributaries contribute practically no water at the critical seasons. While the Feather, Yuba and American Rivers are first magnitude streams with large annual run-offs, they are not spring-fed such as the Upper Sacramento, and their low flow amounts to only a few hundred second feet, which is entirely diverted in critical seasons by agricultural interests along those streams.

With the figures in mind that the normal low flow of the Sacramento is 4500 second feet and the extreme low flow 2800, the existing rights to divert from the river below Red Bluff and above Sacramento are somewhat as follows:

The Division of Water Rights has issued permits for about 4800 second feet. Unapproved applications are approximately 2000 second feet more. These figures do not indicate the actual amount of water which will be diverted, since each permit includes some unirrigable land, or some portion of its land must lie fallow each year, or perhaps some portion of the right will be forfeited through non-use. From the records of use of water on these projects at present on file at the Division an estimate is made that the applications and permits now before the office will ultimately be issued licenses or final water rights, to about 3600 second feet.

From records of water pumped and such other information as is available it is estimated that about 2000 second feet should be allowed for the total of other used rights, both appropriative and riparian, on the river, making a total of about 5600 second feet of actual existing rights by use, or which may be secured under applications now pending.

There are in addition large areas of riparian land along the river which have not as yet used water and if Section 11 of the Water Commission Act regarding riparian rights is overruled by the courts possibly 2000 second feet more would be ultimately demanded by these lands, making a total of around 7500 second feet. Adding

up the total claims on the river, without reducing them in accordance with actual use, brings up the total to over 10,000 second feet.

Assuming the rights by use to be about 5600 second feet, and with only 2800 second feet available at Red Bluff this year, the natural question is, how do these lands get sufficient water? The answer is that not all holders of water rights exercise them, there is a very considerable return flow, and very strict conservation measures were adopted, as it was apparent as early as January, 1924, that the situation was very serious and a water conference was held at that time. As a result of this the Division of Water Rights was asked to appoint a Water Supervisor for the season of 1924 and as I will explain further on, this work has had a high degree of success.

Summarizing the figures quoted you will note that there are rights by use to the waters of the River to an estimated figure of 5600 second feet, which is just double the 1924 low flow of 2800 second feet; therefore, considering only irrigation above Sacramento it would seem the supply is fully appropriated and that new projects will be forced to store winter waters.

Salinity

However, irrigation in the Sacramento Valley above Sacramento is only one angle and these irrigation projects only one of the interests having a claim upon the River. An equally important claim comes from the Delta Region below Sacramento. This area is little known in spite of its vast importance to the State of California. The Sacramento-San Joaquin Delta contains 390,000 acres of highly productive lands requiring irrigation, and is estimated to produce annually crops valued at between 50 and 70 million dollars. The Delta farmers secure their water supply from either the Sacramento or the San Joaquin River or from the many sloughs which traverse the region and connect the two rivers. During the irrigation season their supply mainly comes from the Sacramento and penetrates through the sloughs into the San Joaquin Delta as well, since the low flow of the San Joaquin River is comparatively small, around 400 second feet. The elevation of the Delta lands is just about sea level and the water channels are of course many feet below sea level, therefore, they may be considered arms of San Francisco Bay and the only reason why the salt water

does not come up into the Delta is that the fresh water from the two rivers keeps it out. As fresh water supply diminishes in the summer the salt water creeps farther and farther into the Delta Region. This situation has been getting worse year by year due to a variety of causes, but principally due to the depletion of the summer flow of the Sacramento River by irrigation diversions. The Delta landowners claim water rights both by riparian rights and appropriation and also claim the right to have enough water in the River to keep the salinity condition below the danger point, and have stated that for this purpose it is necessary that 3500 second feet be allowed to pass Sacramento. You will note that this is considerably more water than there was available in the River above diversions during the past summer.

The salinity situation is alarming and of the greatest importance. Residents of Sacramento are probably not aware that salinity to the extent of 25 parts per 100,000 appeared at Freesport, 10 miles below Sacramento, and that if no conservation measures had been taken this year it is probable that the Sacramento domestic supply would have been contaminated by salt from the ocean.

A number of solutions have been suggested for the salinity problem. At the present time investigation is under way to determine whether or not a dam across the Bay itself at Carquinez Straits or at some other point is feasible. Very large storage of winter waters in order to supply this necessary water to the Delta Region is also under consideration.

Navigation

A third important interest on the river is the navigation interest represented by the United States Government through the Army Engineer's office. Navigation on the river below Sacramento is at the present time of great importance and is of some importance above Sacramento, although in low seasons like 1920 and 1924 navigation has been abandoned above this city. However, it is admitted that the United States Government has the paramount right in the waters of a stream in the interests of navigation and could force upper diverters, if it so chose, to release enough water for the purposes of navigation. Major U. S. Grant, the Engineer officer in charge in this District has stated that from 3000 to 3500 second feet in the River above Sacramento would satisfy navigation requirements.

Thus we have three interests, each of which apparently need all the water in the Sacramento River in the summertime during a low season. The interests of the Delta Region and navigation would seem to be somewhat the same; that is, if the United States Government should require 3000 or 3500 second feet for navigation purposes this would supply the Delta with all the water which they state they need.

Sacramento municipal supply

The amount and quality of the water in the Sacramento River is of course of vital importance to the City of Sacramento, since it derives its municipal supply from that source. On account of the considerable amount of return water from the upper irrigation projects it can be stated that there will always be a sufficient quantity of water in the River to supply Sacramento's needs, but quality is a different question. The quality of any return irrigation water is poor, and the return water from rice irrigation on the heavy lands of the upper valley is especially so, since the water has stood on the rice fields for many weeks practically stagnant and when released contains not only rotted vegetation but the accumulation of salts leached out from the lands, making it an undesirable domestic supply even when filtered. In this connection there is no question but that the Sacramento filtration plant during the past summer has justified its existence, as the water during the late summer was impossible as a domestic supply in an unfiltered condition. The River went down as low as 700 second feet, most of which was return water.

The future outlook for domestic supply for the City from the Sacramento River does not appear bright to the speaker. It has been shown that the irrigated area in the Valley is but a small fraction of the area which will ultimately be irrigated, that this development is proceeding at a very rapid rate, and that the water which would reach this city during the late irrigation season is mainly return water of a very poor quality. I do not know the relative impurities of the Sacramento River water nor to what degree a filter plant is effective. It would seem to me that the condition regarding impurity of water is bound to increase. As the Valley settles up more thickly, which it is certain to do, it will be difficult to keep human pollution out of the River. The River is a natural drain for the Sacramento Valley and is bound to receive its impurities. In addi-

tion, it is the speaker's belief that California is entering or will soon enter upon a great industrial development and that the cheap power of the Sierra Nevada Mountains will produce factories, cities, and large population in the Sacramento Valley, and consequent pollution in the River.

I have outlined some of the more pressing problems on the Sacramento River. While the past season has been one of subnormal rainfall throughout the State, this condition has been especially marked in Northern California and the drainage area of the Sacramento River and has brought to a focus many problems which had the growth of the development in the Valley been slower would have been more or less taken care of in the natural course of events.

The rate of development of the whole Valley including the Delta has been so rapid that the inhabitants have not been able to consider the larger problems developing on the River as a result of their own activities. The difficulties, however, cannot be longer ignored. A suit has been filed by the Delta landowners, some 149 in number against 500 upper diverters of water in both the Sacramento and San Joaquin Valleys. This suit has not come to trial and it is the earnest hope of the most constructive interests on both sides that it will not come to trial. The history of water litigation in California proves conclusively that water matters of this magnitude cannot be satisfactorily settled in court.

At the Sacramento Water Conference before referred to which was held in Sacramento last January these various problems with their suggested solutions were discussed very thoroughly by the leading experts, engineers and others, of this part of the State. A report containing the various papers was printed as the Proceeding of the Sacramento Conference, and to anyone interested in this subject it contains a great deal of exceedingly valuable information.

The Conference appointed a committee of twelve representing the various interests in the two valleys with instructions that they should, in the words of the resolution "Prepare a program of the coördinate adjustment and development of all irrigation, power and navigation interests with a view to securing the utmost conservation and use of the waters of the Sacramento and San Joaquin Rivers and their tributaries for the protection and benefit of all."

The Committee, realizing that the immediate task was to get through the 1924 season with as little loss as possible, asked the coöperation of the Division of Water Rights and a Water Super-

visor was appointed to have charge of the River during this season. The cost of the work, nearly $20,000, was raised by a subscription from the landowners, power companies, commercial and other interests involved. The strictest possible conservation measures were adopted and carried on through the entire irrigation season, and it is now possible to judge what has been accomplished.

The Water Supervisor has recently submitted a report in which by comparison with other years he estimates where the salinity condition would have been destructive without conservation measures. Totalling the acreages of the various crops included in this area which would have been damaged, these figures have been submitted to experienced and conservative landowners and farmers of the Delta Region who have estimated the net loss which would have occurred, had they not received water after the dates estimated. Adding up the figures resulting from this estimate, it is found that many millions of dollars worth of crops were undoubtedly saved through the conservation program and through the splendid cooperation extended by the up-river and down-river people in the season's campaign.

With this successful season's work accomplished, the Sacramento Committee and Division of Water Rights have determined to hold another water conference early in December, at which time it is hoped to make the next substantial step in the right direction toward the solution of the general problem.

THE DEVELOPMENT AND MANUFACTURE OF THE MODERN CEMENT LINED SERVICE PIPE[1]

By Reeves J. Newsom[2]

The use of cement as a lining for water pipes was patented by Jonathan Ball in 1843. For some twenty-five years thereafter its use was limited by the fact that there were in existence relatively few public water supply systems.

Shortly after the Civil War many cities began the construction of water works, and, in New England especially, it was recognized that soft surface waters were of a highly corrosive nature and an interior protection for service pipes was desirable. The common type of water main at that time was a cement main, made by covering a thin wrought iron pipe with cement both inside and out. It was natural, therefore, that the same material should be used to line the service pipes and for the next few decades this was the common type of service pipe in New England.

In other sections of the country where other kinds of water were used and where it was not common practice for the water departments to put in the service pipes, other types were adhered to. At that time, the house piping was largely lead and where plumbers were allowed to install the services it was natural that lead should be the material used. Because of the cost and also because some waters absorbed dangerous amounts of lead, the less expensive iron pipe unlined was tried. It was successful only where very hard waters were used or where the lime content was so high that a deposit was formed on the inside of the pipe, automatically giving the same result as a lining of cement so far as the prevention of corrosion was concerned.

About 1890 there appeared on the market iron pipes lined with tin or lead. This type of pipe was theoretically an ideal pipe, as the soft metal lining combined with a strong outer casing would

[1]Presented before the Water Works Manufacturers Association meeting, New York Convention, May 20, 1924.

[2]Commissioner of Water Supply, Lynn, Mass.; Treasurer, Cement Lined Pipe Co.

produce a flexible non-corrosive service pipe. Because of the unsatisfactory results obtained with cement lined service pipe when improperly made, and the inability to obtain good joints at the coupling many waterworks began the use of the soft metal lined pipes. Unfortunately, however, it has not been possible to produce a pipe which bore out the theory, first because the loose lining originally used would collapse, and later because the thin lining formed hot around a mandrel could not be made without minute imperfections which allow water to come in contact with the iron in the presence of the soft metal of the lining and the acid used to stick the two metals together.

In 1916, the writer, upon taking charge of the Water Department at Lynn, Mass., found the service pipe situation very acute, as with only a little over 12,000 services there were required about 2500 cleanouts yearly. A great many of these services leaked upon cleaning and had to be renewed, some after only six or seven years' service. After studying the question at some length it was decided that the solution to the service pipe problem, wherever corrosive waters were to be handled, lay in a properly made cement lined pipe with a method of insuring positive contact of the linings at the fittings. This decision was based largely on the fact that in those cities that are fortunate enough to have used cement lined pipe from the beginning, renewals and cleanouts of services are almost negligible factors in the maintenance of the water department.

The question of the effect of the space occupied by the lining on the delivery of a pipe proved, after experiment with unlined pipes in service a short time, to be no question at all. It is a fact, though seldom realized, that every installation of unlined pipe is unconsciously oversized. When an inch pipe is put in only about a half inch water-way can be counted on as an average over a period of years. On reflection, it is obvious that this practice of oversizing, in the hope that sufficient water-way will remain open to serve for a reasonable period of years, is not good engineering. The fallacy lies in the fact that the process of encrustation continues and conditions requiring maintenance or renewal of the pipe arise long before the life of the pipe itself is anywhere nearly spent. It is much better to put in a lining which a half century's use has shown will make the interior of the pipe of indefinite life, allowing this lining to reduce the initial carrying capacity of the pipe with the assurance that the water-way over a long period of years will not be reduced beyond its original size.

A practical cement lining must not be of unnecessary thickness, it must attain strength rapidly enough to be handled in a relatively short time, and it must be flexible enough to withstand the bending and shocks when carted over rough streets or thrown by freight handlers, and to allow the pipe to be bent in the form of an easy sweep around boulders, conduits, or other obstructions commonly encountered in a service pipe trench.

The writer, after several years' experimenting, has developed such a mixture and for a year and a half the Cement Lined Pipe Company has been shipping cement lined pipe to over thirty cities and towns under a guarantee against injury to the lining. This mixture is a Portland cement, modified to give the required characteristics. It does not set so rapidly that it can not be worked easily and it does not become brittle after seasoning. It does, however, get its strength rapidly enough so that the pipe may be shipped in six days after lining. The method used by this company is basically the same as that devised by Ball, but the tools employed have certain features which center the lining in the pipe except where rough spots occur. At such points the lining is automatically thickened to cover these roughnesses as the tools center themselves in the clear opening through the pipe.

The difficulty at the couplings experienced by the old time users of cement lined pipe was due to their attempts to get a joint between two relatively brittle substances by screwing them together, that is, a cement lining in both pipe and fitting. It was early recognized by the writer that a good joint could be made only by the use of a soft metal lining in the fittings which could conform itself to the shape of the harder cement lining of the pipe. At the same time it was realized that a type of joint should be devised which would do away with the necessity of cutting the cement lined pipe with a hack saw and allow the ordinary wheel cutter to be used.

We developed, therefore, our lipped lining for fittings which is made by forming on the inner circumference of a heavy lining of either lead or tin, a lip of appreciable length so placed that it will clear the burr made by the pipe-cutter. This lip will extend into the pipe, cover the small portion of iron exposed by the slight breaking back of the cement and make a tight contact with the cement lining of the pipe. This results in a lapping of linings which covers not only the threads of the fitting, but the end face of the iron pipe as well. All that is required to insure this result is to smooth the break

in the cement with a few turns of a reamer so that the lip will ride onto the cement evenly.

Cement lined pipe has several advantages over all other types of pipe for the carrying of corrosive waters. Lead lined pipe costs about 50 per cent more than cement lined. Cement lined pipe has no harmful effect on any water. Lead sets the instant it cools slightly leaving minute holes where the lining does not fuse before cooling. Cement remains semi-plastic for some time after the lining is placed and will flow into any small imperfections in the lining as first formed. If there do remain any slight holes in the cement there form merely specks of ordinary rust as a result, whereas similar imperfections in a lead lining result in a rapid galvanic action which eats holes in the outer pipe in a very short time. The same advantages hold when comparing cement lined with tin lined pipe, except, of course, the difference in cost is even greater.

A steel or wrought iron pipe lined with cement has advantages over iron size brass. It is equally non-corrosive on the interior, but even if it is a size larger to allow for the space occupied by the lining, the cost is from a third to a half less. Brass cannot stand as heavy stress as either of the other materials and bursts more readily when frozen. At the point where the threads are cut a very weak section remains which, when subjected to the strains of unequal trench settlement, will often break. Many waters attack brass pipe in a way either detrimental to health or destructive to the pipe.

Lead pipe is, of course, more flexible than any other type, but as compared with cement lined it is more expensive, is less resistant to high stresses, and is easily damaged by the workmen of other public utilities with equipment under the streets. Then, too, the danger of lead poisoning is always present and recent investigation by the Massachussetts General Hospital of Boston has shown that there exist many cases of slow lead poisoning which, because of symptoms common to other diseases, have not, up to the present, been charged up to that insidious cause. As a result, the early lowering of the safe limit of lead content for drinking water may be expected.

There are now several dozen water departments in cities and towns of all sizes using cement lined service pipe and new ones are being added every month. The use of cement to protect pipes from corrosion is only in its infancy and in a few years good engineering

practise will demand that all mains as well as service pipes, where corrosive waters are to be handled, shall be lined with cement. Several engineers have taken up this question with us and have suggested that we perfect a method for lining large pipes. This we are now doing.

It is generally recognized that water becomes much more active corrosively after filtration. Further, it is indicated that in a relatively short time the public will demand the softening of hard waters and this will further increase their corrosive activities. It is evident, therefore, that to derive full benefit from cast iron pipe, which is good for generations so far as outside corrosion is concerned, a lining is required. Cement best meets the requirements for an easily installed, relatively cheap lining. The trend of this movement towards cement lining is shown by the fact that the specifications for the new filtration plant at Providence, R. I., now being advertised, call for cement lined laterals and ask for a price on lining effluent pipes up to 30 inches in diameter.

WATER PURIFICATION PLANT DESIGN AND OPERATION[1]

By Stanley T. Barker[2] and Harry F. Ferguson[3]

Most of those present know that the rules of the State Department of Public Health require that plans for proposed new water supplies or for changes and additions to existing supplies involving the sources of supplies or methods of handling, treating, or storing the water, be submitted to the Division of Sanitary Engineering of the Department of Public Health for review and approval. Therefore, it may be of interest to know just what points are given the most consideration when water purification plant plans are received for such review.

PURIFICATION AND NOT STRUCTURAL FEATURES REVIEWED

Plans are reviewed to determine the ability of plants built according to them to clarify and purify water satisfactorily and to a certain extent economically. Plans are not reviewed as to structural stability.

KNOWLEDGE OF EXISTING PLANTS OF VALUE

The detailed studies and the continuous check on the operation of existing plants in the state that have been and are being made by the Division of Sanitary Engineering, combined with certain knowledge relative to some plants in other states, the requirements of other state sanitary engineering divisions, and a review of published articles dealing with water purification give a good basis upon which to judge plans.

IMPROVEMENTS IN DESIGN ENCOURAGED

Effort is made to be fair and open-minded when reviewing plans and especially toward any unusual design or new development.

[1] Presented before Illinois Section meeting, March 19–20, 1924.

[2] Senior Assistant Sanitary Engineer, State Department of Public Health, Springfield, Ill.

[3] Chief Sanitary Engineer, State Department of Public Health, Springfield, Ill.

If an experienced engineer incorporates in his plans some new idea which has not been tried out elsewhere and there is no experience or evidence to prove that the new feature will not work or be satisfactory the engineer is given the benefit of the doubt and the plans are approved. The engineer and community for which the plans are prepared, however, are advised that the Division of Sanitary Engineering can not guarantee the new feature, but is agreeable to seeing it tried. In this way improvements in design are encouraged and the possibility of interfering with progress in the art and knowledge of water purification is avoided.

EXPERIENCED ENGINEERS RECOMMENDED

Plans are submitted for review by engineers of varied experience in water-purification-plant design and operation. In some cases a single comment or suggestion for improvement in the plans can not be made. In other cases the engineers have been advised that the plans are so incomplete and worthless that it is not worth while trying to revise them and we advise them to secure an engineer experienced in that kind of work to help them on the design.

COMPLETE PLANTS DESIRABLE

If the finances of a community are such that it cannot afford a purification plant which conforms to best practice in every respect the plans may be approved provided the design is such that additions can be made later readily and at reasonable expense. Such approval is given only after it is evident that a more complete plant cannot possibly be financed at the start and the community is advised of the shortcomings of the plant.

DATA ON EXISTING PLANTS

The Division of Sanitary Engineering has recently completed a tabulation giving detailed data on all the water-purification plants in the state, and it is from this tabulation that the following facts have been deduced.[4]

There are at present 49 water-purification plants[5] in actual operation and 4 under construction. There are several others proposed or ready for construction.

[4] Copy can be obtained on request to Illinois State Department of Health.

[5] Does not include plants comprising only chlorination.

The largest plant is at East St. Louis which has a nominal capacity of 27.3 million gallons per day. The plant at Evanston is second at present and even with the proposed increase in capacity to 24 million gallons per day it will still be second. The smallest plant is at Mascoutah, with a capacity of 0.12 million gallons per day, and the next smallest is the 0.36 million-gallon per day plant at Warsaw.

All except 5 plants in the state have gravity filters as distinguished from pressure filters. Several other plants originally had pressure filters which were later converted to operate as gravity filters and sedimentation basins were added. Of the 5 exceptions, 3 are old plants, 2 of which treat Lake Michigan water and do fairly well when the turbidity is low, while the other is used only in emergencies to treat Fox River water and operates at a very low rate. The fourth exception is the pressure filter in a water-softening plant. The fifth exception is a plant built comparatively recently and against the advice of the Division of Sanitary Engineering. This plant has been in service for three years and has never furnished a satisfactory water. The operating cost has been excessive and extensive and expensive changes will be required to make the plant even reasonably satisfactory.

A large majority of the plants have capacities of 1½ million gallons per day or less, 35 of the 49 being in this group and nearly all the proposed new plants will be of less than 1½ million gallons per day capacity.

There are 2 single-unit filter plants in the state. One of these is in a water-softening plant which is operated intermittently and where filtration is not required to improve the sanitary quality of the water. The other plant handles a water that is very turbid at times and when the filter is out of service for any reason, it is more or less impossible to provide a satisfactory water by the use of only alum and chlorine. Of the other plants in the state 20 have two filter units, 8 have three units and the rest have four or more.

MORE THAN TWO FILTER UNITS RECOMMENDED

Where a plant has to be operated nearly up to capacity, the provision of two units does not give very much flexibility and in case of any prolonged release from service of one unit, the single filter remaining in service will have to be seriously overloaded. At

least three units, therefore, are recommended wherever considerable excess filter capacity will not be provided.

FILTER CAPACITIES

Filter capacity is computed on the basis of 2 gallons per square foot of sand surface per minute (125 million gallons per acre per day). We have found that this rate does not impose an excessive load on the filters where the sedimentation capacity is reasonably adequate and where the filters are kept in proper condition. It is possible that this rate may be exceeded with safety in plants treating Lake Michigan water, (except at seasons when algae are causing trouble), but with the more polluted and more highly turbid water from the streams and reservoirs downstate, this rate should not ordinarily be exceeded, and where the preliminary treatment given the water is inadequate, the rate should be reduced.

UNDERDRAINS

Underdrains have a dual function. They have to collect the water uniformly from all parts of a filter and have to distribute the wash water uniformly over the area of a filter.

With the customary type of underdrain, which comprises a large central manifold and laterals extending to the sides of the filters, it is necessary to have the sizes so proportioned that the pressure during washing is about the same at all parts of the system. This is usually accomplished by deciding on the total area of the openings in each lateral and making the area of the laterals enough times greater than this total that uniform distribution is secured along the laterals, and then by making the area of the central manifold enough times greater than the total area of all the openings to obtain uniform distribution along the manifold. We have found that where the proportions of the laterals and manifold are not adequate unequal distribution of wash water results.

The area of openings in the laterals should not be so small as to cause an excessive loss-of-head and on the other hand should not be so large that an unequal distribution of wash water will result if the manifolds and laterals are kept of economical size. Plans are checked on the basis of the laterals having an area about 3 times the area of the openings and the manifold having about $1\frac{1}{2}$ times the area of the openings if the wash water enters the manifold

at the end. An area of openings of 0.2 to 0.3 per cent of the filter area is considered satisfactory.

GRAVEL

The gravel depth must be sufficient to distribute the wash water uniformly before it reaches the level of the sand and the size must be adequate so that it will not be displaced by the entering wash water. Where insufficient or too small gravel is used, we expect to find unequal distribution of wash water and a tendency for the sand and gravel to become intermixed. For a high velocity wash 15 to 18 inches of gravel ranging in size from $1\frac{1}{2}$ to $2\frac{1}{2}$ inches at the bottom to $\frac{1}{8}$ inch at the top is considered satisfactory.

SAND

Where an insufficient depth of sand or where a too large or nonuniform sand is used the filter effluents have been found less satisfactory than where an adequate depth of proper-sized sand is used. The uniformity of the sand is important also because a nonuniform sand will tend to segregate laterally as well as vertically, the finer material moving to one side of the filter while the coarse sand moves to another place because of slight inequalities in the distribution of wash water. This, of course, results in unsatisfactory bacterial efficiency.

The standard adopted for sand is that it shall have an effective size of between 0.35 and 0.45 millimeters and a uniformity coefficient of less than 1.6. Most of the well-known water filter sands on the market meet this specification and some of the natural sands can be washed and scraped to meet this specification. A sand depth of 27 to 30 inches is considered adequate.

WASH TROUGHS

Wash troughs too close to the sand surface will waste sand and if too high an excessive amount of wash water will be required to clean the filters. If the spacing between troughs is too great, causing long travel of the dirty wash water, the washing will be inefficient and unsatisfactory. A lateral travel of 36 inches is the maximum that should be used and 30 inches or less is to be preferred. If the troughs are not of adequate size, they will submerge during a wash and reduce the efficiency of the wash.

The elevation of the trough crests is somewhat dependent on the size of sand used and the actual rate-of-wash available, but with a 24-inch wash a height of crest of 22 to 24 inches is usually satisfactory. Computing trough sizes for any rate-of-wash is not simple. We have found that sizes computed by the method given in Ellm's book on water purification are usually adequate and not wastefully large.

FILTER PIPING

The size of the filter piping and whether the supply of wash water is adequate in quantity and pressure have to be considered together, because the size of the wash-water main has a bearing on the pressure required to be furnished by the wash-water pump or tank, and the rate that the water will be used determines the size of sewer branch and mains that must be provided. We have found poorly designed plants where some one feature of the design has set a limit on the rate-of-wash that could be used and thus had influenced the plant efficiency very markedly. Practically all the new plants are reasonably satisfactory in these respects, but some of the older plants are badly handicapped by their inability to keep the filters clean and in good condition.

RATE CONTROLLERS AND LOSS-OF-HEAD GAGES

Engineers do not ordinarily send in plans which do not provide for rate controllers and loss-of-head gages, but occasionally an engineer who is designing a small plant in which these "accessories" are an important item of cost, will bring up the point that many plants are not using their rate controllers or gages and that they are not really necessary.

The water-treatment tabulation prepared by the Division of Sanitary Engineering shows the rate controllers of about 13 of the plants are not in service and an even larger number of the plants are not using their loss-of-head gages, but while we recognize that plants can be run without these "accessories" we do feel that a consistently safer filtered water will be produced by a plant where the rate-of-filtration is kept from being excessive by rate controllers, and where the condition of the filters is shown at all times by loss-of-head gages. Also the operation will be easier and more economical where the controllers and gages are kept in service.

Various types of controllers are in use and we make no recommen-

dation regarding the type to choose. All require attention, some more than others, but where a properly designed controller or gage has been installed, it appears to indicate a certain slackness on the part of the operators when these are allowed to get out of service for any length of time.

COAGULATION, MIXING AND SEDIMENTATION

The sedimentation basins and appurtenances such as the mixing basins and coagulant feeding devices should be such as to reduce the load on the filters to a reasonable amount. There is only one plant in the State where the water is given preliminary sedimentation before the coagulant is applied, and this provision seems to be justified by the comparatively moderate chemical dosage required to treat the turbid and highly-polluted water of Mississippi River.

The coagulating chemicals are fed in solution at all but 6 of the plants and in 3 of these 6 the alum is fed in solution, so the experience with dry-feed apparatus in this State has been rather limited. The operators at the plants which have dry-feed machines, seem to feel that they are satisfactory. This is contrary to the experience in Ohio, where the consensus of opinion of the operators was that solution feed was more reliable.[6]

After the coagulant is fed into the water at a rate which is proportionate to the flow of raw water, and considerable thought has to be expended so that this will be possible, the next point is to see that the chemical shall be thoroughly mixed with the water so that a suitable floc will be developed by the time the water enters the sedimentation basin. Of the 53 plants in operation or under construction, 26 have mixing basins, and mixing basins are under consideration for several others. At some of the other plants the alum is added to the water on the suction side of the low-service pump which gives a fair degree of mixing but provides no contact period before the water enters the sedimentation basin.

Experience at several of the plants where mixing basins have been used and abandoned and then used again shows conclusively that a mixing basin is worth while even where the retention provided is small, if only the agitation secured in the basin is adequate, and we,

[6] Reports of Conferences of Ohio Water-Treatment Plant Operators.

therefore, require that all new plans make provision for mixing basins.

The retention periods in the mixing basins now in service range from two-tenths to forty minutes and the velocities developed by the baffles range from 2 to 80 feet per minute. Of course, the mixing basin in which the velocity is only 2 feet per minute is useless for mixing and really serves only as an extension to the sedimentation basin.

For new plants we usually require that the retention periods be at least ten to twenty minutes and the velocities developed shall be 30 feet per minute or more. Experiments by the United States Public Health Service have shown that it may take twenty minutes or more for floc to form where an optimum alum dose is being applied, and other experimenters have shown that the best mix is secured when the velocity is from 40 to 60 feet per minute and the basin is baffled so that the flow is reversed as abruptly and frequently as possible. Therefore, we feel that our requirements are not unreasonable and we believe that a plant where an adequate mix is provided will show a considerable saving in amount of chemicals used over one where mixing is not arranged for. Smaller mixing basins using paddles or other mechanical agitators may be used.

The principle of the sedimentation basin is, of course, rather simple in that it is merely a place where the velocity of the water is slowed down to a point where the matter in suspension will have an opportunity to settle out before the water leaves the basins. It has been shown mathematically and theoretically that the efficiency of a basin depends merely upon its area and that the depth has no bearing, but practical considerations prevent the use of large shallow basins, or the use of a number of horizontal baffles in a deep basin which has been proposed. It has been found that 10 to 12 feet is about as shallow as the average basin can be made economically because a certain allowance has to be made for the accumulation of sediment. Most of the basins, except in the very very largest plants, are about this deep.

Another feature that is both theoretically and practically desirable is that the course of the water through the basin shall be straight, with no turns to cause eddies and dead spaces. This channel in open basins must not be too wide or eddy currents will be developed by wind action and these will interfere with sedimentation. Wherever it is impracticable to design the basins with a straight course

for the water, effort should be made to limit the turns and dead spaces to keep down the formation of eddies as much as possible.

The details for inlets and outlets and for passing the water from one basin to another in the case of two basin plants, should be such as to reduce eddies to a minimum and prevent unequal distribution of water across the cross-sectional areas of the basins.

The question as to how much retention to provide is dependent on the type of raw water to be treated and the amount of money the city can afford. The original filter plants did fairly good work without any or with limited sedimentation basins, but at a tremendous cost for chemicals and wash water. Although a certain amount of sedimentation capacity must be considered as necessary to reduce the load on the filters to a point where they will yield a safe water, the exact amount is rather an economic problem of how much the city can afford to spend to obtain a certain decrease in operation cost.

The retention provided in the various plants ranges from none to eighteen hours and the average seems to be about four hours. We have come to feel that four hours is about the minimum retention that should be provided for a plant to handle the heavy turbidity from the Illinois clay soils, but when water from very large reservoirs or from Lake Michigan is to be treated, it may be safe to reduce the retention, although the algae in the lake and reservoir water frequently make large sedimentation capacity desirable.

After the amount of retention has been decided on, it is necessary to determine whether to divide the retention between two basins or to use just one, depending on the mixing basin alone while the single sedimentation basin is out of service for cleaning. Two basins are preferable, especially if the plant has to be operated continuously and nearly up to capacity, but if considerable excess filter capacity is provided and the amount of money available is limited, it may be satisfactory to provide a single basin at the start.

CLEAR-WATER STORAGE

When only limited clear-water storage is provided, the rate-of-filtration has to be varied frequently to keep up with the consumption. This is undesirable and we believe that sufficient storage should be provided so that the rate-of-filtration can be kept constant for considerable periods. It is also necessary to supply storage sufficient for adequate fire protection, and we feel that we can

not give unqualified approval of any plans which do not provide the storage called for by the National Board of Fire Underwriters. In some cases piping arrangements have been made which will permit of pumping raw water into the mains in the case of large fires, but such connections have been the cause of much sickness in the past and we can not regard them as satisfactory substitutes for adequate filtered-water storage.

The foregoing points are among the most important ones that are considered in reviewing filter-plant plans. There are other minor points which are checked, but which need not be included in this rather general paper.

COMPACT AS TO THE WATER RESOURCES OF THE DELAWARE RIVER BETWEEN THE COMMONWEALTH OF PENNSYLVANIA, THE STATE OF NEW JERSEY AND THE STATE OF NEW YORK

This compact defines the rights of the states of New York, New Jersey and Pennsylvania in the waters of the Delaware river, which forms the boundary between them. It gives to each state the right to develop tributaries within its own borders in accordance with its own regulations governing such matters, but puts a restriction on the total which may be developed.

It prohibits the drying up of the river below any dam and requires that at all times a quantity greater than the minimum flow must be left in the stream.

It divides the water in the channel of the Delaware river above Port Jervis equally between the three states and below Port Jervis equally as between New Jersey and Pennsylvania. The share of each state, however, is automatically reduced in proportion as it may make developments on the tributaries.

It constitutes the channel of the Delaware river as a carrier for water developed on a tributary or by a dam across the channel, in order that water so developed may be carried to any point lower down, where it may be taken out of the channel.

It provides for the construction of dams across the river for storage or for power development and for intakes to make possible the removal of water from the river.

A means is provided for any injured party, either within or without the state that creates the damage, to secure just compensation.

Rules of sanitation are laid down. A policy for forestation on the Delaware watershed is stated and hydro-electric development of power is specifically provided for.

Joint projects between two or more states are authorized and provision is made for the settlement of controversies between states and a permanent commission to approve of projects and to observe their operation is provided for.

Disclaimers are incorporated as to existing treaties, interference with existing riparian rights and vested rights of diversion.

In a word, it will be possible under the compact to develop the latent resources of the Delaware river to their fullest extent for hydro-electric power, for water supply or for any other purpose. Up to the present time the water which these resources represent has flown to waste because of the uncertainty as to what any state might do in the way of conserving them. This compact defines the rights of the states and confers great benefits on all of them.

The compact is reprinted here in full because of its importance to all water works workers as a demonstration of inter-state coöperative handling of used and useful waters.

COMPACT

The Commonwealth of Pennsylvania by Legislative Act, approved the twenty-fourth of May A.D. 1923 (Pamphlet Laws 448), and the State of New Jersey by Chapter 94 of the Laws of 1923, and the State of New York by Chapter 56 of the Laws of 1923, having authorized their respective Governors to appoint Commissioners for the purpose of negotiating a form of compact or treaty between the said three states, and the said states through their Governors having appointed as their Commissioners:

CHARLES H. MINER, ROBERT Y. STUART, PHILIP P. WELLS,	*for the Commonwealth of Pennsylvania*
WILLIAM A. STARRETT, FREDERICK C. SCHNEIDER,	*for the State of New Jersey*
GEORGE MACDONALD, RUDOLPH REIMER, JEFFERSON DEMONT THOMPSON,	*for the State of New York*

who, after negotiations, have agreed upon the following articles:

ARTICLE I

This compact, between the sovereign states of Pennsylvania, New York and New Jersey, is entered into for the purpose of conserving by storage and otherwise for all uses the water resources of the said states in the Delaware river, its tributaries and drainage area and, as a means to that end, for making allotments from the said water resources to the said states respectively and determining and adjusting their respective rights therein.

Article II

Where used in this compact, singular words shall be construed as including the plural, masculine words shall be construed as including the feminine and neuter, and the following terms and expressions shall have the meanings as respectively designated for each:

The term "waters of the Delaware river" means all of the surface waters which, following their natural courses, flow into the channel of the Delaware river above that point in the said channel which marks the boundary between the states of Delaware, Pennsylvania and New Jersey.

The term "channel of the Delaware river" means the lands and bed of the river on and over which the waters of the Delaware river flow, beginning at that point near "Monument Island" which is the northeastern corner of the Commonwealth of Pennsylvania and extending thence continuously as the said channel winds and turns to the point which is the common boundary between the states of Pennsylvania, New Jersey, and Delaware.

The term "drainage area of the Delaware river" means the entire area of both land and water from which the surface waters naturally flow into the channel of the Delaware river.

The term "tributary" or "tributary of the Delaware river" means any watercourse, the waters of which naturally reach the channel of the said river.

The term "domestic and municipal" as applied to the use of water means the use of water by or for waterworks serving the public.

The term "sanitation" as applied to the use of water means the use of water for the conveyance of sewage and industrial wastes.

The term "sewage" means any substance or liquid containing any of the waste products or excrementitious or other discharges from the bodies of human beings or animals.

The term "industrial waste" means any liquid or solid substance, not sewage, resulting from any process employed in manufacturing or industry.

The term "water returned" or its equivalent means the return into a tributary or into the channel of the Delaware river of water after the same has been used for any purpose and in this sense the terms "sewage" and "industrial waste" shall be construed as being "water returned."

The term "industry" as applied to the use of water means the use

of water for manufacturing and industrial purposes in all cases in which the water used is not taken from a public water supply system.

The term "power" as applied to the use of water means the use of of water for the development of energy whether that use be direct or indirect.

The term "navigation" as applied to the use of water means the use of water for transportation and for the operation of water craft for all purposes.

The term "develop," "developed" or "development," when referring to the use of water from the channel of the Delaware river or a tributary shall include any means for making the water available for use by the construction of any intake, dam or other works.

The term "point of development" means the point nearest the mouth of a tributary at which any dam or intake is built in connection with any development of the waters of such tributary.

The term "divert" or "diversion" when referring to water in the channel of the Delaware river means the taking or removal of water from the said channel when the water taken or removed is not returned into the said channel within a distance of twelve miles below the point of diversion measured along the center line of the said channel.

The term "divert" or "diversion" when referring to the water of a tributary of the Delaware river means the taking or removal of water from that tributary or from any portion thereof when the water taken or removed is not returned into the channel of the Delaware river either above the point at which the tributary enters the said channel or within a distance of twelve miles below that point, measured along the center line of the said channel.

The term "point of diversion" means the point or place at which water is taken or removed from a tributary or from the channel of the Delaware river.

The term "developed for diversion" means conservation of water by storage or otherwise on or from any one or more tributaries for the purpose of diversion at any point on the tributary or tributaries, or at some lower point in the channel of the Delaware river after the water shall have reached said lower point as water in transit.

The term "ordinary flow" means a flow of forty-five hundredths (0.45) of a cubic foot per second for each square mile of drainage area above the point at which the "ordinary flow" is to be determined.

The term "ordinary low flow" means a flow of fifteen hundredths (0.15) of a cubic foot per second for each square mile of drainage area above the point at which the "ordinary low flow" is to be determined.

The term "allotment" means the share of any signatory state in the water flowing in the channel of the Delaware river which is in excess of all water in transit.

The term "New York-New Jersey state line" means the boundary line between the states of New York and New Jersey, which line, for the purposes of this compact, shall be considered as crossing the channel of the Delaware river due east to the so-called "Tri-State Rock" and continuing thence in a southeasterly direction across the Neversink river to a rock on the west shore of the Hudson river near the village of Nyack.

The term "water in transit" means water which has been developed by storage or otherwise and which is flowing in the channel of the Delaware river under the provisions of Article VII.

The term "point of storage" means the point or place in the channel of the Delaware river at which a dam is maintained.

The term "Commission" means the Tri-State Delaware River Commission.

Article III

In the development, use or diversion of the waters of the Delaware river and in all considerations of quantity and preservation of quality the order of importance and public value of water shall be as follows: (A) domestic and municipal, (B) sanitation, (C) industry and power, and (D) navigation.

Article IV

Any administrative department, political subdivision, corporation, partnership, association or person authorized in that behalf by or under the laws of any signatory state may exercise the rights and privileges herein conferred on such state, subject to the duties and obligations herein imposed on such state.

Article V

Any tributary or any part of any tributary of the Delaware river may be developed for any purpose by or under the authority of the signatory state in which it is located, and water so developed may be diverted for use at any point either within or without the drain-

age area of the Delaware river. In case water so developed is diverted, then the following restrictions and limitations shall apply:

(1) Every such development shall be carried out in compliance with the legislative provisions governing such matters in the state in which it is located.

(2) Every such development shall be so planned and the works shall be so constructed as to bring about the greatest practicable conservation and use of the waters of the tributary on which it is located.

(3) In the case of every such development located above the New York-New Jersey state line there shall be maintained below the point of development during the months of July, August, September and October a reserve flow equal to the ordinary flow at that point, and also if at any other time during the year the flow in the tributary at the point of development is less than the ordinary flow at that point, then a reserve flow equal to the ordinary flow shall be maintained below the point of development. In the case of every such development located below the New York-New Jersey state line there shall, at all times, he maintained below the point of development a reserve flow equal to the ordinary low flow at that point.

(4) The total drainage area in any state which may be developed for diversion under the provisions of this article shall not exceed three-fifths of the drainage area of the Delaware river which lies within that state.

Article VI

All water which, at any time, is flowing in the channel of the Delaware river above the New York-New Jersey state line and which is in excess of all water in transit in said channel is alloted to the states of New Jersey, New York and Pennsylvania, and with the approval of the Commission, as provided in Article VIII hereof, each of these states may divert from the said channel at any point, above the said state line, that portion of its allotment which is in excess of a reserve flow of fifteen hundredths (0.15) of a cubic foot per second for each square mile of drainage area above the point of diversion and at any point below the New York-New Jersey state line each of the said states may divert that portion of its allotment which is in excess of a reserve flow of twelve hundredths (0.12) of a cubic foot per second for each square mile of drainage area above the New York-New Jersey state line. The allotments of the respective states shall be computed from time to time as follows:

In case no tributary within the drainage area above the New York-New Jersey state line shall have been developed for diversion, then the allotment of each state, at any point in the channel of the Delaware river above the said state line, hereinafter called the normal allotment, shall be one-third of the total water which may, at any time, be flowing in said channel at that point. In case one or more tributaries within said drainage area shall have been developed for diversion by only one of the signatory states, then the respective allotments of the signatory states shall be determined by the following rule: The allotment of said diverting state shall be determined by subtracting from its normal allotment an amount to be computed by multiplying said normal allotment by a fraction, the numerator of which shall be the total drainage area developed for diversion on said tributaries within that state above the New York-New Jersey state line and the denominator of said fraction shall be the total drainage area above the said state line; and the allotment of each one of the other two states shall be determined by adding to its normal allotment one-half of the amount subtracted from the allotment of the diverting state. In case tributaries within the drainage area above the New York-New Jersey state line shall have been developed for diversion by two or more states the rule herein above stated shall be applied separately and in turn as to each diverting state, and the subtractions from and additions to the normal allotments of the states, thus determined, shall fix the allotments of the states as of that time.

All water which originates within the drainage area below the New York-New Jersey state line and enters the channel of the Delaware river below that line and which is in excess of all water in transit in said channel is hereby allotted to the states of New Jersey and Pennsylvania and with the approval of the Commission as provided in Article VIII hereof, each of said states may divert from said channel at any point below the said state line that portion of its allotment which is in excess of a reserve flow of eighteen hundredths (0.18) of a cubic foot per second for each square mile of drainage area lying above the point of diversion and below the New York-New Jersey state line. The allotments of the states of New Jersey and Pennsylvania in the waters which originate within the drainage area below the New York-New Jersey state line shall be computed from time to time as follows:

In case no tributary within the drainage area below the New York-

New Jersey state line shall have been developed for diversion, then the allotment of the states of New Jersey and Pennsylvania at any point in the channel of the Delaware river below said state line, hereinafter called the normal allotment, shall be one-half of the water which has originated within the said drainage area and which, at any time, is flowing in the said channel at such point below said state line; in case New Jersey or Pennsylvania shall have developed for diversion one or more tributaries within said drainage area, then the allotment of the diverting state shall be determined by subtracting from its normal allotment an amount to be computed by multiplying said normal allotment by a fraction, the numerator of which shall be the total drainage area developed for diversion on said tributaries within that state below the New York-New Jersey state line and the denominator shall be the total drainage area below the said state line, and the allotment of the other state shall be increased by the amount by which the allotment of the diverting state has been reduced. In case tributaries within the drainage area below the New York-New Jersey state line shall have been developed for diversion by both New Jersey and Pennsylvania the rule herein above stated shall be applied separately and in turn as to each of them and the subtractions from and additions to the normal allotments of the states, thus determined, shall fix the allotments of the states as of that time.

Dams may be constructed across the channel of the Delaware river by or under the authority of any one of the signatory states for the purpose of storing water developed for diversion, water in transit belonging to said state, or any part or all of the water allotted to it under the provisions of this article. All water stored may be diverted or released from such reservoir or reservoirs by or under the authority of such state but the flow in the said channel below the point of storage must not be reduced below the ordinary flow whenever the flow above the point of storage is greater than the said ordinary flow. When and if the flow in the said channel above the point of storage is less than the ordinary flow then and in every such case a flow equal to that above the point of storage shall be maintained in the said channel below the point of storage. At all times, however, neither the water in transit nor the allotment or allotments of the other signatory state or states shall be interfered with but must at all times be permitted to pass such dam or dams.

It is the intention of this article that no water shall be diverted

from the channel of the Delaware river above the New York-New Jersey state line whenever the flow in the said channel is less than forty-five hundredths (0.45) of a cubic foot per second for each square mile of the total drainage area lying above the point of diversion and it is further intended that no water shall be diverted from the channel of the Delaware river below the New York-New Jersey state line whenever the flow in the said channel is less than thirty-six hundredths (0.36) of a cubic foot per second for each square mile of the total drainage area lying above the point of diversion, but nothing contained in this article shall be construed to limit or prevent the diversion of water in transit, of water diverted under any vested right, or of water stored for diversion as herein provided.

Article VII

The channel of the Delaware river is hereby constituted a carrier for conducting water, designated as "water in transit," which has been developed or stored in accordance with the terms of Article V or Article VI. Such water may be removed or diverted at any time or place from the channel of the Delaware river by or under authority of the state under whose auspices the development was made, irrespective of the quantity of water flowing in the channel of the Delaware river and the reserve flow provisions of Article VI. The rate at which such water is released or delivered shall be regulated so far as may be consistent with its economic utilization in such manner as not to unduly interfere with private rights or public interests along the said channel. The daily rate at which such water may be removed or diverted from the channel of the Delaware river shall not exceed the daily rate at which it is released or delivered and no greater quantity may be diverted from the said channel than shall have been released or delivered from the developments made under the provisions of Articles V and VI less the reserve flows provided for in the said Articles V and VI, except that allotted water may be diverted as provided in Article VI. No development or construction in the channel of the Delaware river shall be permitted to interfere with the regularity of the flow of any water which has been released or delivered for carriage.

Article VIII

In order to render possible the utilization or diversion of water flowing in the channel of the Delaware river, each signatory state

shall have the right to build dams entirely or partly across said channel and to construct wing dams, headworks, intakes or other necessary facilities at any point or points in or along said channels, subject to the following limitations and stipulations:

(a) All such works shall be built in compliance with the legislative provisions governing such matters in the state or states in which they are located.

(b) Works for the development of water power may not be built except with the approval of the Commission in accordance with the provisions of Article X hereof.

(c) Approval of the Commission shall be secured for every project which involves the removal or diversion of more than two million gallons of water per day from the channel of the Delaware river; such approval, however, need not at any time be obtained by any administrative department of a signatory state or any political subdivision within a signatory state or by any corporation, partnership, association or person in the case of any intake which is in existence at any point in said channel on the date when this compact becomes effective.

In the exercise of this authority, said Commission shall be governed and its power and authority shall extend to and be limited by the following principles, restrictions and reservations, to wit:

(1) In the case of any project which, in the judgment of the Commission, will not interfere or conflict with any other use of the water flowing in the channel of the Delaware river, the Commission shall approve said project without imposing any restrictions or conditions except such as may be necessary to insure compliance with the provisions of this compact.

(2) As between any one or more proposed or possible conflicting uses, the action of the Commission shall be based upon the relative importance of the uses to which the water may be put, as fixed in Article III of this compact, and to the extent that conflict is irreconcilable, that possible and practicable project which will effect the use of water standing highest in the order of importance shall be approved without restrictions or conditions, except such as the Commission may deem necessary to insure compliance with the provisions of this compact. To the extent that conflict is avoidable by a reasonable modification of any or all of the projects which may be involved, the Commission shall fix the terms of such modification, but such terms shall not require, as against the higher use, pumping in place

of gravity delivery of water, nor impose on the higher use the cost of any impounding works or any unreasonable enlargement of pipe lines, conduits or tunnels, or impose on the higher use any undue burden in either expense or convenience of operation. In the case of conflict in uses of the same relative order of importance, preference shall be given to an established use over a proposed one and the Commission shall have authority to determine the manner in which such conflicting uses may be harmonized, without imposing unreasonable expense or undue burden upon either or any of them.

Article IX

No water from the drainage area of the Delaware river shall be diverted to any point outside of the boundaries of the states signatory to this compact. No one of the signatory states may give, grant or dispose of to another signatory state, or to any holder of an authorization therefrom, any water developed by or allotted to it under the provisions of this compact, except by legislative act when necessary and then only with the approval of the Commission; but nothing herein contained shall be construed to prevent or prohibit the joint exercise by or under the authority of any two or more of the signatory states of the rights conferred by this compact and such joint exercise of rights is hereby authorized.

Article X

With the approval of the Commission any signatory state may construct or authorize the construction of a dam, wing dam, headworks, power house or other structure in or across the channel of the Delaware river for the main purpose of the development of water power. Provided, that every such authorization shall be limited to such period not exceeding fifty years as the said state shall determine and set forth in its authorization. Provided further, that the holder of such authorization shall be entitled to extension and renewal thereof upon the same terms until such holder shall have received, through recapture or purchase by the authorizing state or by a duly authorized subsequent holder of like authority from said state, repayment of the capital prudently invested in the power project upon the faith of the authorization plus such reasonable damages, if any, to property of such holder which is valuable, serviceable and dependent for its usefulness upon the continuance of such authorization, but not recaptured or purchased, as may be caused by the

severance therefrom of property taken. Provided further, that the authorizing state may, in the discretion of its appropriate agency, officer or employee empowered in that behalf, embody in its authorization such other terms, conditions and stipulations as such agency, officer or employee shall deem necessary to protect the present and future interests of each of the three signatory states and their people in the construction, maintenance and operation of the project and in the water and power resources to be utilized thereby and suitable to secure to the holder of such authorization a reasonable opportunity for a fair return on the capital prudently invested in the project. And provided further, that every such authorization shall be on the following conditions, which shall be expressed in such authorization, namely: (a) That the authorization shall become null and void unless, within the time specified therein, the holder of such authorization shall secure from the United States such license, permit or authority as may be lawfully required; and (b) that if and to the extent that any of the rights or powers set forth or reserved as rights or powers of the United States in or pursuant to the provisions of such license, permit or authority shall be waived by the United States or be unenforceable by the United States, then and to that extent such rights and powers (including, if so waived or unenforceable any rights of recapture, extension, or renewal so set forth or reserved), subject to such alterations in plans, specifications, or structures, and such extensions of time for commencing or completing structures, as may have been made or granted by the United States, may be exercised and enforced by the signatory state which originally authorized the construction. No project authorized and constructed under the provisions of this article shall, at any time, be operated so as to injuriously affect any project for municipal and domestic water supply which has been or may be established under the provisions of this compact. Subject to such conditions as the Commission may embody in its approval, water for the development of power may be removed from the channel of the Delaware river and carried in a canal or in a pipe to any point below a dam constructed under the provisions of this article, but said water shall be returned to the said channel within a distance of twelve miles below the point of removal measured along the center line of the said channel and there shall always be maintained in the said channel immediately below the dam, such regular and uniform flow of water as the Commission may determine to be reasonable and proper.

Article XI

In connection with each and every development made under any provision of this compact, there shall be installed and maintained all equipment and apparatus for measuring quantities and rates of water flow, the determination of which may be necessary for the purpose of showing that the development or construction is being operated in compliance with the provisions of this compact.

Article XII

In order to put and maintain the waters in the channel of the Delaware river in a condition sanitary and suitable for the uses and purposes set forth by this compact no sewage or industrial waste shall be discharged or permitted to flow into or be placed in or permitted to fall or move into the channel of the Delaware river or into any of its tributaries otherwise than under the following conditions and restrictions:

(1) All sewage discharged or permitted to flow into the channel of the Delaware river above the confluence with the Lehigh river shall, within a time reasonable for the construction of the necessary works, have been so treated as to remove settleable solids, to render the effluent non-putrescible and to effect a reasonable reduction of B. Coli Communis.

(2) All the sewage discharged or permitted to flow into the channel of the Delaware river below the confluence with the Lehigh river shall, within a time reasonable for the construction of the necessary works, have been so treated as to at least remove settleable solids and shall be discharged through submerged outlets into said channel; provided that such submerged outlets shall be located and constructed as may be required by the Commission; and provided further, that in order to protect the public health in specific instances such higher degree of treatment shall be used as may be determined to be necessary by the Commission after due notice and hearing.

(3) All sewage discharged or permitted to flow into any tributary of the Delaware river, except the Lehigh river, shall be treated to that extent, if any, which may be necessary to maintain the water of such tributary immediately above its confluence with the Delaware river in a sanitary condition at any time at least equal to the sanitary condition at such time of the water of the Delaware river immediately above such confluence.

All sewage discharged or permitted to flow into the Lehigh river shall be treated to that extent, if any, which may be necessary to maintain the water of the Lehigh river immediately above its confluence with the Delaware river in that sanitary condition which the Commission, after due notice and hearing, shall have determined to be necessary because of the nature and extent of the use of the water of the Delaware river below such confluence, provided, however, that the Commission may not require the sanitary condition of the Lehigh river immediately above its confluence with the Delaware river to exceed that of the sanitary condition of the Delaware river immediately above such confluence.

(4) All industrial wastes discharged or permitted to flow into or be placed in or permitted to fall or move into the channel of the Delaware river or any tributary thereof shall first have been treated to such extent, if any, as may be necessary to maintain in the channel of the Delaware river sanitary conditions equivalent to those which would be attained by the treatment of sewage above required in this article; provided, nevertheless, that industrial wastes containing substances likely, in the judgment of the Commission, to produce offensive tastes and odors in any public water supply from the channel of the Delaware river, shall either be wholly prevented from being discharged or from flowing into or from being placed in or permitted to fall or move into said channel or any tributary of the Delaware river, or shall first have been treated to such an extent as to wholly eliminate such taste and odor producing constituents.

This article shall become effective when any one of the signatory states, or any holder of an authorization therefrom, shall have begun the work of construction on any project under the provisions of this compact.

Nothing in this article shall be construed to repeal or prevent the enactment of any legislation or the enforcement of any requirement by any signatory state imposing any additional conditions and restrictions to lessen or prevent the pollution of streams within their several jurisdictions.

In order to maintain the water of any tributary immediately above its confluence with the channel of the Delaware river in a sanitary condition which will meet the requirements set forth in paragraphs (3) and (4) of this article, the administrative determination and enforcement of the degree of treatment, if any, necessary to fulfill such requirements shall be made and undertaken by the proper

officer or agent of the state wherein such tributary lies, provided, however, that any other signatory state or any municipality, citizen or resident thereof or property owner therein or any holder of any authorization therefrom under this compact, shall nevertheless have full right either jointly or severally to sue for the enforcement of any and all of the provisions of this article and for the redress of any injuries which may have resulted by reason of a violation thereof.

Article XIII

The beneficial effects of forest covered areas on the regularization of stream flow, with attendant greater potential use of streams for domestic, industrial and navigation purposes, and the greater stability of public ownership in management for the protection of forested drainage areas is clearly recognized and agreed to by the states party to this compact. Each signatory state hereby adopts and will adhere to a policy covering the establishment and maintenance of an adequate forest cover on public and privately owned land in the drainage area of the Delaware river and the maintenance of the highest practicable standards of protection from fire on these lands.

Article XIV

All lands, water-rights or easements necessary for the construction and maintenance of any dam in or across the channel of the Delaware river may, with the approval of the Commission, be appropriated and condemned by any signatory state or by the holder of authorization therefrom. All damage resulting from the exercise of the right and power of condemnation conferred by this article shall be ascertained, recovered and paid as provided by Article XV hereof.

Article XV

All damage to persons or property resulting from the exercise of any rights under this compact shall be determined under the rule of damages, in accordance with the procedure, and in such manner as is provided by the law of the state in which the damages are suffered. The damages suffered in the State of Pennsylvania shall be ascertained, recovered and paid as provided by the forty-first section of the Act approved April Twenty-ninth, One thousand eight hundred and seventy-four (Pamphlet Laws 73) and the amendments

and supplements thereto. The damages suffered in the State of New York or in the State of New Jersey shall be ascertained, recovered and paid as provided by any general or other act applying thereto in effect at the time when the development is authorized. The court or courts which have jurisdiction of the subject matter in the respective states shall have jurisdiction of the person of every party in interest for the purposes of notice, summons and hearing throughout all three signatory states.

Article XVI

Nothing herein contained shall be construed to abridge any riparian rights under the laws of the several states to the use of water from the channel of the Delaware river or from any of its tributaries except upon payment of just compensation to be ascertained and adjudged by due process of law.

Article XVII

Nothing contained in this compact shall operate to impair any vested right of diversion or use of the waters of the Delaware river which may exist or have become vested at any time prior to the ratification hereof, but the amount of water diverted under such vested right shall be charged against the allotment of the state under whose authority or jurisdiction said right became vested. In each of the signatory states rights to divert or use the waters of the Delaware river or its tributaries, together with property necessary to effect the same, though devoted to public use, may be taken for any other public use higher in the order of importance as set forth in Article III, provided that nothing in this article shall be construed to authorize the taking of vested rights or property without just compensation to be determined by due process of law governing such matters in the respective states.

Article XVIII

Nothing in this compact shall be construed to prevent the institution or prosecution of any proceedings in any court of competent jurisdiction for the purpose of remedying or correcting by damages, injunction, mandamus or other process civil or criminal any act of commission or omission in violation of the provisions of this compact, for the protection of any rights under it, for the enforcement of any of its provisions, or for the awarding and enforcement of payment of

compensation for any injury which may be caused by the exercise of any right or privilege herein authorized.

Article XIX

Nothing in any existing treaty between any two of the states signatory hereto shall be modified or changed or invalidated by anything herein contained except as any provision in any such existing treaty may be expressly repugnant to any provision of this compact, but nothing in any said existing treaty shall be construed to prevent the erection and maintenance of any dam across the channel of the Delaware river, as authorized or permitted under the provisions of this compact.

Article XX

The governor of each of the signatory states is hereby directed to designate an appropriate state officer or employee and may appoint not more than two other persons all of whom shall serve, until their successors are designated or appointed, on a joint Commission to be known as the Tri-State Delaware River Commission. In voting on all matters which come before the Commission, each signatory state shall have one vote and no decision or approval shall be rendered by the said Commission except on the unanimous vote of the three signatory states. Every decision rendered by the Commission shall be accompanied by a certificate of the Commissioners to the effect that the said decision is for the best public interest and is in compliance with the provisions of this compact. The Commission in rendering every decision shall therein fully state the reasons on which its action in the premises was based.

The Commission shall meet annually on the first Wednesday in October, the first annual meeting to be held at Trenton, New Jersey and subsequent annual meetings shall be held at such place or places as the Commission may determine. The powers and duties of the Commission, in addition to those hereinbefore set forth, shall be as follows:

(1) To make rules and regulations respecting the government of its organization and the conduct of its business.

(2) To appoint from among its members a Chairman, a Vice Chairman and a Secretary and to hold meetings at such times and such places as it may determine.

(3) To set up and require the keeping of a comprehensive system

of stream flow and other measurements as may be necessary to determine:

(a) The amounts of water diverted and released under any provision of this compact.

(b) The maintenance of the required reserve flows below all points of development and diversion.

(c) All other facts and data requisite for determining that the provisions of this compact are at all times being complied with.

(4) To report annually to the governors for the information of the legislatures of the signatory states as to the developments and projects which have been begun and completed under the terms of this compact and as to such other matters as may come within its purview.

(5) To observe the operation of all developments and to issue such orders as may be necessary to require compliance with any of the provisions of this compact.

(6) To proceed with a study and investigation looking toward a complete and comprehensive development of all the water resources of the drainage area of the Delaware river and to report the results of such study and investigation to the governors of the signatory states for the information of the respective legislatures.

(7) To make a study of the possibilities for the development of water power along the channel of the Delaware river and to designate tentative locations and heights of dams along the said channel.

(8) The Commission or any member or any duly authorized officer, agent or representative shall have power to and is hereby authorized to enter without let or hindrance upon the lands and property upon which any or all projects and developments are being constructed, operated or maintained under any authorization provided by this compact. Each state through its appropriate departments shall cooperate with the Commission as the said Commission may require in obtaining such data, information and records which may be necessary to enable said Commission to exercise its powers and duties.

(9) The attorney general of each signatory state or a deputy shall serve as the legal adviser of the commissioners representing that state.

(10) The Commission shall have the power to compel the attendance of witnesses and the production of any papers, books, documents and records for any purpose that may be necessary to ascertain that the provisions of this compact are at all times complied with, and any member of the Commission shall have power to administer

oaths to all witnesses who may be called before it. Subpoenas issued by the Commission shall be signed by one of the members thereof within the jurisdiction of the state from which he has been designated and may be served by any person of full age. The fees of witnesses required to attend before such Commission shall be Five Dollars ($5.00) for each day's attendance and ten cents ($0.10) for each mile of travel by the nearest generally traveled route in going to and from the place where the attendance of the witness is required, such fees to be paid when the witness is excused from further attendance, and the disbursements made in payment of his fees shall be audited and paid in the same manner provided for the payment of expenses of said Commission; provided, however, that no witness subpoenaed at the instance of parties other than such Commission shall be entitled to compensation therefrom for attendance and travel, unless the Commission shall certify that his testimony was material to the matter investigated and necessary or essential for the effectuation of this compact. If the person subpoenaed to attend before the Commission, or a member thereof, fails to obey the command of such subpoena without reasonable cause, or if a person in attendance before such Commission, or a member thereof, refuses, without lawful cause, to be examined or to answer a legal or pertinent question or to produce a book or paper or other document when ordered so to do by the Commission, or any member thereof, the Commission, or such member thereof, may apply to any court of general jurisdiction in the state or country wherein such testimony is taken or to be taken, and such court, or any judge or justice thereof, shall have power, upon proof, by affidavit, of the facts to make an order, returnable in not less than two days nor more than ten days, directing such person to show cause before the court, or the justice thereof, who made the order, or any other justice or judge having jurisdiction, why he should not comply with the subpoena or order of the Commission. Upon the return of such order, the court or justice or judge before whom the matter shall come on for hearing shall examine such person under oath, whose testimony may be relevant, and such person shall be given an opportunity to be heard, and if the court or justice or judge shall determine that such person refuses without reasonable excuse to obey the command of such subpoena or to be examined or to answer a legal or pertinent question or produce a book, document or other paper, which he was ordered to produce, said court or justice or judge may order such person to comply forth-

with the subpeona or order of the Commission, and any failure to obey such order of the court or justice or judge may be punished by said court or justice or judge as a contempt of such court. No person shall be excused from testifying or producing any books, papers or other documents subject to the authorization of this article upon the ground that his testimony might tend to incriminate him or to subject him to a penalty of forfeiture. But no person shall be prosecuted, punished or subjected to any penalty or forfeiture for or on account of any act, transaction, matter or thing concerning which he shall, under oath, have testified or produced documentary evidence, and no testimony so given or produced shall be received against him upon any criminal or penal investigations or proceedings; provided, however, that no person so testifying shall be exempt from prosecution or punishment for any perjury committed by him in his testimony. Nothing herein contained is intended to give or shall be construed as in any manner giving to any corporation immunity of any kind.

(11) The appropriate department of each signatory state represented by the Commissioner designated under the provisions of this article shall, as the Commission may determine, furnish at the cost of the three signatory states in equal shares all such equipment, service and facilities as will enable the Commission to properly and efficiently exercise the powers and perform the duties defined in this article. All expenses of the Commission shall be paid, share and share alike, from funds provided by the signatory states, said funds in each state being made available to that department of the state which is represented by the officer or employee designated by the governor as a member of the said Commission and all said expenses shall be paid from said funds on the certification of the said designated state officer or employee or in such other manner as the laws of the signatory state may prescribe.

Article XXI

Should any claim or controversy arise between any two or more of the states signatory to this compact with respect to the meaning or performance of any of the terms of this compact, or in case it should become desirable to modify any provision or all of this compact, then the governor of each state affected, upon the request of any one of them, shall each forthwith appoint a Commissioner empowered to jointly consider and adjust such claim or controversy

or recommend such modification subject to ratification by the legislatures of the signatory states and, the Congress of the United States having consented thereto, such modification shall be in full force and effect.

Article XXII

Should any part of this compact be held to be contrary to the Constitution of any signatory state or of the United States all other severable parts of this compact shall continue to be in full force and effect.

Article XXIII

This compact may be terminated at any time by concurrent legislative action of all the signatory states. In the event of the termination of this compact all rights and obligations which may have become established or vested under its provisions shall remain and continue unimpaired. Said termination shall be subject to such terms and conditions as may be agreed to by the signatory states.

Article XXIV

This compact shall be submitted for adoption to the legislature of each of the signatory states at their several sessions beginning in the month of January, 1925; and upon adoption by the legislative act of each and all of said states, the Congress of the United States having consented thereto, it shall be in full force and effect.

In Witness Whereof, the Commissioners have signed this compact in triplicate originals, one of which shall be deposited with the Secretary of State of each of the signatory states.

Done at the City of New York, New York, this twenty-fourth day of January, in the year of our Lord, one thousand nine hundred and twenty-five.

Charles H. Miner
Robert Y. Stuart
Philip P. Wells
W. A. Starrett
Frederick C. Schneider
George MacDonald
Rudolph Reimer
J. D. Thompson

Preparatory Negotiations Leading to Compact

The legislatures of the three states early in 1923 authorized their Governors to appoint commissioners to consider the situation on the Delaware River and this compact is the outgrowth of their deliberations. Pennsylvania was represented by Dr. Charles H. Miner, Commissioner of Health, as Chairman, Robert Y. Stuart, Secretary of Forests and Waters, and Philip P. Wells, Deputy Attorney General; New Jersey by W. A. Starrett as Chairman and Frederick C. Schneider; New York by George MacDonald as Chairman, Rudolph Reimer and Jefferson DeMont Thompson. These three commissions organized as a Joint Commission by selecting George MacDonald as Chairman, Charles H. Miner as Vice Chairman and W. A. Starrett as Secretary. The compact was drafted by a committee of technical and legal advisors consisting of, for Pennsylvania Charles E. Ryder, Chief Engineer of Water and Power Resources, George W. Woodruff, Attorney General and Philip P. Wells, Deputy Attorney General; for New Jersey, H. T. Critchlow, Hydraulic Engineer, Department of Conservation and Development and Francis H. McGee, Deputy Attorney General; for New York, J. Waldo Smith, Consulting Engineer, Board of Water Supply, City of New York and Frank H. Deal, Esq. Thaddeus Herriman, Chief Engineer of the Board of Water Supply, City of New York, acted as Consulting Engineer to the technical advisers on the drafting committee. Colonel John R. Slattery of the Corps of Engineers, and Colonel William Kelly of the Federal Power Commission represented the United States Government.

This compact is a long step in advance in the way of the settlement and determination of state rights in interstate waters. It is the first agreement of its kind among our eastern states and the principles on which it is based have resulted in a distribution and allocation of the waters of the Delaware River in a manner which will best result in their use and development and which is just and fair and equitable to each of the interested states as well as to their peoples. Under this compact Philadelphia and her environs as well as the metropolitan districts of New Jersey and New York will secure the right to obtain supplies of potable water sufficient to meet all of their requirements for many years to come.

The outcome of the negotiations leading up to the signing of this compact constitutes a splendid example of the results and benefits

which may be secured by direct agreement rather than by a determination of rights through litigation in the courts. This negotiation is but the forerunner of many others and will undoubtedly come to serve as a precedent on which they will be based.

WATER SUPPLY FOR TOWNS[1]

By Lafayette Higgins[2]

The problem of a safe and adequate water supply for the average town is difficult, perplexing and sometimes exasperating. Difficult for natural reasons, perplexing from financial complications and exasperating because of indifference on the part of the people concerned.

Town supplies have usually been installed for fire protection at first, the supply, in most cases limited, being furnished by a single small tubular well or a dug well of small storage capacity; and in most cases the daily supply from such sources running perhaps from 3000 gallons to 10,000 gallons. In a few instances nature has been kind and the supply is sufficient.

No town or village is too small to evade the problem of some form of public water supply; likewise no town or village is too small to require some form of community sewage disposal.

An ordinary use of water in the sewage disposal soon reveals the deficiency in the water supply. A town of 700 population with a sewer system needs about 40,000 gallons per day. Many such towns in Iowa have less than 25,000 gallons daily supply, some towns have less than 10,000 gallons and a few towns have less than 5000 gallons daily supply. The larger towns and the small cities present similar conditions and in some cases the conditions are extreme.

The problem of an increased water supply, therefore, confronts the people of the average town just as plainly as it confronts the people of any town where no supply has been attempted, and these conditions are so general that we may well feel that the real problems in Iowa lie in supplying the towns with an adequate water supply.

The small town desires a naturally filtered water. Unless in a region where shallow wells may penetrate extensive and prolific water bearing sand and gravel beds, a diligent program of water prospecting is necessary to locate the desired supply, and it is fre-

[1]Presented before the Iowa Section meeting, November 7, 1924.

[2]Consulting Engineer, Des Moines, Iowa.

quently true that the final location of the supply may be very remote from the town, necessitating a comparatively heavy outlay to collect and deliver the water to the distributing system in the town.

It is of little use for the authorities of the town to employ a fancy priced water engineer who may copy a few chapters of the Iowa Geological Report, make a hurried visit to the locality and prepare a lengthy typewritten report dealing in generalities and possibilities in so bewildering a manner that the council can deduce no practical procedure therefrom. What is needed in such cases is an intelligent practical investigation in which test wells are the main asset. If a town is not willing to adopt such a procedure there is little hope of betterment, only such as may come accidentally. That some towns have taken the practical road and have been successful may lead others to do the same. There are many municipal engineers that may design distributing systems, but there are very few that can successfully develop a water supply.

Financing a water supply, or the extension of the same, is perplexing at the present time. The average town of 700 population may have a bonding power of $40,000 with the people willing to vote from $15,000 to $25,000. If the town wants a deep well it will require all they are willing to vote. If by chance a tubular well 50 to 100 feet deep can be located in the town the supply may be installed for about $25,000 by limiting the distributing system. If the source of supply must be a mile or more out of town it may require the entire amount voted to develop the source of supply and deliver the water to the elevated tank in the town, leaving the distributing system out of the account. Here is where the proposition of assessing the cost of the distributing system, or the greater part of it, to the abutting and adjacent property as special assessments, would solve the problem.

The proposition of assessing cost of mains to the abutting and adjacent property will doubtless be presented to the next General Assembly of Iowa. A similar proposition assessing the cost of such water mains against the benefitted property, up to the cost of a six inch water main, was introduced in the last two Assemblies, losing the first time because of neglect in the closing days of the Assembly, and losing the last time because the contractors objected to a provision of the bill allowing a city to install its own mains without contracting, up to the amount of $10,000.

The failure to pass this legislation prevented several towns from securing water works during the last two years. It is to be hoped that such favorable legislation may be passd by the next General Assembly, and water works officials and town councils should render all possible aid in securing such legislation.

The exasperating indifference of the people to water improvements in many cases is fatal to the best efforts of the water officials. The demand to lessen taxes prevents the outlay no matter how necessary to the health and lives of the people the proposed water improvements may be. The necessary improvements may be a matter of $10,000, only to be met by violent opposition by some of the influential people and put to rest. Again the proposition may require $20,000 which may be unthinkable to the influential ones. With such opposition an entire system is almost out of the question at the present time, especially when such a system would approximate $40,000.

In a locality where wells are impossible and it is a question of impounding and treating the water, the total cost may even be far beyond the real financial ability of the town, but whether this is so or not such a proposition receives scant consideration at the present time at the hands of the people who are sorely in need of the benefits to be derived.

It is not the purpose of this discussion simply to make complaints. The attempt is to call attention to the necessities of the small cities and towns and to impress upon the reader the necessity of conserving the interests of the smaller communities and assisting these communities to better their conditions.

There are always plenty of those who seek to work in the larger communities where the problems are also difficult and extensive. There are so few competent water works people interested in the smaller communities that the work in such communities is so poorly engineered by other unprepared people that the people interested received far less benefit than would be possible otherwise. If the discussion will result in a more helpful attitude on our part the purpose of the discussion will have been accomplished.

DISTURBING FACTORS IN THE PRESUMPTIVE TEST FOR B. COLI

By Gordon B. Leitch[1]

The matter of the presumptive test for the presence of B. coli has been repeatedly brought to the attention of bacteriologists over a considerable period of time. Two reasons for this may be advanced: (1) the importance of detecting B. coli in infected waters, (2) the irregularities noticed in the presumptive test.

That the production of gas by B. coli, when growing in lactose broth, is considered only a presumptive test for that organism indicates that it does not fulfil all the requirements of a specific test. Chief among the defects is the production of gas when no B. coli can be demonstrated.

Frost (1) and scores of other workers have reported considerable variation in the presumptive test, as regards the demonstrability of B. coli. Numerous reasons for this irregular gas production have been advanced. Klein (2), Creel (3), and others have reported gas in lactose broth produced by anaerobic spore-forming bacilli. That this is a considerable source of the irregular gas formation is somewhat doubted by Meader and Bliss (4). E. M. Meyer (5), and others, have isolated aerobic spore-forming bacilli which give gas in lactose broth. Levine (6) confirmed this, and he advocated, as had Hall and Ellefson (7) previously, the use of gentian violet of various strengths to inhibit these organisms.

Sears and Putnam (8) have recently offered some explanations of gas production that seem applicable to this problem. They found that gas was produced by organisms in symbiosis, when none of the organisms concerned would produce gas when growing in pure culture, in the same medium. They concluded that the medium, inoculated with a symbiotic complex (two or more organisms), was first attacked by one of the organisms present, and that a second organism produced the gas by taking advantage of a stage in the decomposition due to the first. Most of their work was done with the usual cultures

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constituting a laboratory stock, chiefly pathogenic organisms. Their suggestion that this might have a bearing upon the failure of the presumptive test for B. coli seemed quite reasonable, and it was decided to investigate this phase of the question.

In considering the problem it was deemed essential to investigate from a dual standpoint. The first problem was to ascertain whether individual members of gas producing complexes were to be met with frequently in natural locations, from which they might easily gain access to a water supply. The second problem was to determine whether gas forming complexes occur in water samples giving a positive presumptive test, yet which are negative for B. coli.

SYMBIOTIC GAS PRODUCTION IN LACTOSE BROTH WITH ORGANISMS ISOLATED FROM SAMPLES SELECTED AT RANDOM

This phase of the investigation was concerned solely with the detection of organisms capable of becoming members of a gas producing complex, in water, soil, sewage, or such other locations from which they might readily enter a water supply, consequently no attention was given to the occurrence together, in the samples, of the different members of a complex.

Samples were obtained from a variety of sources, over a wide territory, including Oregon, Washington, Idaho, British Columbia, Alberta and Saskatchewan.

A portion of each sample obtained was inoculated into lactose broth, and another portion into nutrient broth for use as a stock culture. From the 48 hour culture on lactose, streaks were made on lactose litmus agar. From these plates, individual colonies were fished, and inoculated into nutrient broth. From these twenty-four hour cultures, the organisms isolated were transferred to lactose, and glucose, broths. Cultures giving gas on lactose were of course discarded. The remaining organisms, with their fermentation reactions as a basis, were divided into two groups, and various combinations of representatives of these two groups were inoculated into lactose broth, in large Smith fermentation tubes, and incubated at 37°C. At the end of forty-eight hours gas readings were recorded. As far as possible, equal amounts of the various cultures were used, the inoculation in each case being a loopful of the organism, from a 24 hour culture in nutrient broth. The inability of the organisms to produce gas from lactose, in pure culture, was established by special controls for each symbiotic complex.

In the tables given herewith, the number of any particular organism has to do solely with the numerical order in which it was

TABLE 1

CONSECUTIVE NUMBER OF CULTURE	SOURCE	GLUCOSE		LACTOSE	
		Acid	Gas	Acid	Gas
1	Swimming Pool	+	−	+	−
2	Sewage	+	+	−	−
3	Well	+	+	−	−
4	Sewage	+	−	+	−
5	Water	+	+	−	−
6	Well	+	+	−	−
7	Sewage	+	−	+	−
8	Sewage	+	−	+	−
9	Water	+	−	+	−
10	Water	+	+	−	−
11	Water	+	−	+	−
12	Water	+	+	−	−
13	Sewage	+	−	+	−
14	Well	+	−	+	−
15	Well	+	−	+	−
16	Well	+	−	+	−
25	Water	+	+	−	−
26	Sewage	+	+	−	−

TABLE 2

Gas production by symbiotic complexes

(Selected at Random)

CONSECUTIVE NUMBER OF COMPLEX	CONSECUTIVE NUMBER OF ACID FORMER	CONSECUTIVE NUMBER OF GAS FORMER	PER CENT GAS FORMED
1	1	2	5
2	4	3	10
3	9	5	15
4	13	10	Trace
5	17	6	10
6	14	10	5
7	15	12	15
12	16	5	35
23	18	10	30
24	19	25	5
33	4, 9	3, 5	25
29	4	2 + 3 + 10 + 26 + 25	20
30	9	26 + 6 + 25	25
42	1 + 4 + 11 + 9 +13	3	35

isolated. The specific identification of the cultures was not considered necessary to this phase of the investigation.

Table 1 gives the fermentation reactions of the different pure cultures in lactose, and glucose, broths. Table 2 gives the gas readings in lactose broth of the various combinations that were tested. A comparison of the two tables will show at once that a combination producing gas in lactose broth contained at least one organism capable of fermenting lactose with acid production, and at least one organism capable of fermenting glucose, with gas production. This confirms the findings of Sears and Putnam. For convenience, the two types of organisms are listed separately in table 2. Negative tests are not included in the table. It may be stated, however, that the absence of either of the above types of organisms assured the non-appearance of gas.

The gas percentages given were selected at random from a number of repeated tests in which the results often varied within fairly wide limits. Those given undoubtedly represent a fair approximation to the average experience. The causes of the variation were not determined. It will be readily noted that the gas percentages obtained in the tests are, in a majority of the cases, high enough to be interpreted as a positive presumptive test for B. coli, ten out of the fourteen recorded combinations giving 10 per cent or more gas.

SYMBIOTIC GAS PRODUCTION BY ORGANISMS ISOLATED FROM WATER SAMPLES GIVING A POSITIVE PRESUMPTIVE TEST, BUT NEGATIVE FOR B. COLI

This phase of the investigation was concerned with the detection of gas forming complexes in samples of water giving a positive presumptive test, yet which were negative for B. coli. Several such samples of water were obtained through the courtesy of the director of the Oregon State Health Laboratory.

A broth culture was made from each sample obtained, experience having shown that some of the organisms died if left in an acid medium, such as existed in the discarded presumptive test tube. From the twenty-four hour broth cultures, each sample was inoculated into a large Smith fermentation tube, containing lactose broth, and incubated at 37°C. At the end of forty-eight hours gas readings were recorded, and streaks were made (or pour plates where necessary) on lactose litmus agar. From these plates, forty-eight

hours later, individual colonies were fished and transferred to nutrient broth, to serve as stock cultures for further study. Particular attention was paid to their fermentation reactions on lactose, and glucose, serum waters and broths. All the organisms from one sample were next re-inoculated together, in large Smith fermentation tubes containing lactose broth, and incubated at 37°C. At the end of forty-eight hours the gas formed was recorded. These figures are given in the last column of table 3.

Of the fifty samples tested, all but two failed to show organisms giving gas on lactose. In both these cases the organism concerned

TABLE 3

Symbiotic gas production by complexes isolated from positive presumptive tests, negative for B. coli upon confirmation

PRESUMPTIVE TEST NUMBER	SOURCE	GAS PER CENT WHEN OBTAINED	GAS PER CENT UPON INOCULATION	NUMBER OF ORGANISMS ISOLATED	ACID FORMERS	GAS FORMERS	GAS PER CENT UPON RECOMBINATION
272	Creek	10	0	1	1	0	0
277	Spring	20	20	4	3	1	20
284	River	30	20	3	1	2	20
288	Well	Trace	Trace	1*	—	—	Trace
303	Well	20	10	3	2	1	20
312	Spring	10	10	1*	—	—	10
329	River	40	0	3	2	1	0
330	River	Trace	10	2	1	1	10
578	River	30	30	2	1	1	35
654	Pool	20	20	4	3	1	20
662	Spring	Trace	20	2	1	1	15
717	Stream	20	20	2	1	1	25

* Spore-forming lactose fermenter.

was a spore-former. It will be seen that symbiotic complexes were isolated from many of the remaining tests. It further appears that each gas producing complex contains at least one representative of each of the two types of organisms referred to above. Recombining the organisms isolated from a sample in many instances resulted in as much gas formation as in the original sample, and in some cases more.

The acid forming organisms, in the series of tests examined, were for the most part gram-positive, non-motile, non-sporing organisms, growing readily on the usual laboratory media. The ma-

jority of these were chiefly streptococcus non-hemolyticus I and fecalis (Holman). Several were staphylococci; a few were streptococcus hemolyticus I (Holman).

The gas forming organisms were in every case found to be bacilli, most of which grew fairly well on the ordinary laboratory media.

TABLE 4

Characteristics of Organism

CONSECUTIVE NUMBER	MORPHOLOGY OF ORGANISM	GRAM STAIN	SPORES	MOTILITY	LIQUEFACTION GELATIN	INDOL PRODUCTION	GLUCOSE		LACTOSE		SACCHAROSE		MALTOSE		HEMOLYSIS OF BLOOD	MANNITE	SALICIN
							Acid	Gas	Acid	Gas	Acid	Gas	Acid	Gas			
1	Streptococcus	+	−	−	−	−	+	−	+	−	+	−	+	−	+	−	+
2	Bacillus, long, slender	−	−	+	−	−	+	+	−	−	−	−	+	+			
3	Bacillus	−	−	+	−	−	+	+	−	−	−	−	+	+			
4	Bacillus	−	−	−	−	−	+	−	+	−	−	−	+	−			
5	Bacillus	−	−	−	−	−	+	+	−	−	−	−	+	+			
6	Bacillus	−	−	+	−	−	+	+	−	−	−	−	+	+			
7	Bacillus-thick	−	−	+	+	−	+	−	+	−	+	−	+	−			
8	Streptococcus	+	−	−	−	−	+	−	+	−	+	−	+	−	−	+	−
9	Bacillus	−	−	+	−	−	+	−	+	−	+	−	+	−			
10	Bacillus	−	−	+	−	−	+	+	−	−	−	−	+	+			
11	Staphylococcus	+	−	−	+	−	+	−	+	−	+	−	+	−	−	−	−
12	Bacillus	−	−	+	−	+	+	+	−	−	+	+	+	+			
13	Staphylococcus	+	−	−	+	−	+	−	+	−	+	−	+	−	−	+	−
14	Bacillus	−	−	+	−	−	+	−	+	−	+	−	−	−			
15	Bacillus	−	−	+	+	−	+	−	+	−	+	−	+	−			
16	Staphylococcus	+	−	−	+	−	+	−	+	−	+	−	−	−			
17	Streptococcus	+	−	−	−	−	+	−	+	−	+	−	+	−	−	+	+
18	Bacillus	+	−	+	−	−	+	−	−	−	+	−	−	−			
19	Streptococcus	+	−	−	−	−	+	−	+	−	+	−	+	−	−	−	−
25	Bacillus	−	−	+	−	−	+	+	−	−	−	−	+	+			
26	Bacillus	−	−	+	−	−	+	+	−	−	−	−	+	+			
27	Bacillus	+	+	−	−	−	−	−	−	−	−	−	−	−			
28	Bacillus	+	−	−	−	−	+	−	+	−	−	−	+	−			

Several of these were gram-negative, non-sporing, motile organisms, which produced acid and gas on glucose, but failed to alter saccharose, or produce indol; these appear to be organisms related to the paratyphosus enteritidis-hog cholera group. A smaller number fermented sucrose, and produced indol, and appear to be members of the B. proteus group.

In addition to those named above, the bacillary forms encountered included some members of the subtilis, fecalis alcaligenes, and fluorescens types. Many of these were inert as far as the symbiotic complex is concerned. Six Gram-negative bacilli were found for every five Gram-positive bacilli; of these Gram-positive bacilli only about 10 per cent had any effect upon the gas producing properties of the complex.

Table 4 gives in detail the characteristics and cultural reactions of the organisms encountered.

From the small number of samples tested, it is obvious that no general conclusion can be drawn as to the percentage of occurrence of these gas producing complexes in water, and their importance as an explanation of the non-confirmation of B. coli in samples giving a positive presumptive test. The material available in a large water laboratory would be better suited, than that at our disposal, to an investigation of this question.

In the present investigation it has been demonstrated that organisms belonging to the types shown by Sears and Putnam to be capable of producing gas symbiotically from lactose broth occur widely distributed in nature and in locations from which they may readily enter a water supply. It is further shown in a definite small number of instances, that samples of water, negative for B. coli, but giving a positive presumptive test, actually contained gas producing symbiotic groups.

That the occurrence together of organisms belonging to the two groups mentioned does not necessarily lead to gas formation is evident. Symbiotic gas production in the absence of either of these groups, however, did not occur.

REFERENCES

(1) Frost: American Journal of Public Health, 1906, 6, pp. 585–8.
(2) Klein: Local Govt. Board Report, 1901, p. 104.
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DEVELOPMENT AND MANUFACTURE OF SURVEYING AND OTHER ENGINEERING INSTRUMENTS[1]

By W. L. Egy[2]

DEVELOPMENT

The first transit, as we know it today, was designed just about one hundred years ago and was the same in principle as those now used. The design of Wye and Dumpy Levels is only little more than one hundred years old. Those early instruments would look very crude to us today and would be quite unsatisfactory, but only on account of convenience, materials and workmanship. There has been one important feature of design added during the last one hundred years, that is, the stadia for measuring distances, and the Beaman Arc which reduces inclined stadia readings to their true vertical and horizontal values. Outside of this, however, the development of our engineering instruments during the past one hundred years has followed the development of manufacturing methods, and simply represents the increased knowledge of materials and how to use them. There has been some study of details of design for the convenience of the operator in using his instrument, and for the convenience of the manufacturer in making the parts; and the improvement in workmanship which results in better made pieces and standardized parts.

This does not mean that new ideas are never proposed, for W. and L. E. Gurley receive offers of probably 100 patents or new ideas every year. Practically all of these suggestions are technically correct, and can be made quite useful by the men who invented them. They nearly always have one of two faults, however. Many of them require intricate and complicated manufacturing methods and could not be made without a prohibitive cost.

Other ideas which might be adopted at a reasonable manufacturing cost are so radical in their appearance or use, that it would require

[1]Presented before the Water Works Manufacturers Association meeting, New York Convention, May 20, 1924.

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a considerable sales cost to persuade the American engineer to buy them. It is surprising how much trouble it is to sell even a slight change in what the engineers consider a standard instrument, or at least the standard appearance of instruments. The cost of selling so small a thing as a round head clamp screw instead of a wing head is sometimes equal to a large part of the profit on the instrument, and this is in spite of the fact that the arguments, except that of custom, are in favor of the round head screw.

For this reason, the new Gurley transit has the same general appearance as the old Gurley transit, (and is not *much* different from other makes), although almost every piece in the instrument has been changed or improved in some way or other.

A brief description of some of the many problems encountered in developing a suitable design, in finding the proper materials to use, and improving the workmanship of a transit will show the extreme care which is taken to supply the surveyor with the best tools possible.

But first let us see if we can get a picture of the usual shop as it existed seventy-five years ago. There were less than a dozen men and the owner worked his 10 hours a day with the others. Any necessary correspondence was handled at night. The few machines were foot power lathes on which hand tools were used. There was one crude graduating machine operated by hand. Each man made an instrument complete. No piece would fit any other instrument.

Every man had to make his own tools, including drills, taps and dies. There were no recognized standards for screw threads, and it was the practice to make one screw at a time to fit the particular hole in which it would be placed.

It was in 1849, just seventy-five years ago, that Mr. William Gurley installed a steam boiler and engine for power, and was much ridiculed for being so extravagant.

Now with this picture in our minds, let us turn to the study and development of the transit as it is being made today.

MATERIALS

Metals

The materials used in these instruments are of the utmost importance. They must of course be free from iron. Some of the factors which must be considered in choosing casting metals for engineering instruments are stiffness, ability of machine, foundry

technique, friction, coefficient of expansion, and aging. Two alloys have been developed by W. & L. E. Gurley after two years intensive study of metals, working under the direction of one of the best equipped non-ferrous metallurgical laboratories in the United States.

Strength

In the first place, a certain amount of rigidity or stiffness is required in the metal, while elongation is not required. A tensile test is the proper check upon the strength of the metal used.

One characteristic which has not been measured to any considerable extent is the frictional property or ability to rub against another surface without cutting. The practical working friction of moving parts is almost impossible to measure because of the many variables. A frictional testing machine measures the force necessary to start the sockets in motion.

Better results are generally obtained when the two rubbing surfaces are of different structure, but the two metals must have the same temperature coefficient of expansion. If this were not the same, the unequal changes in size between zero weather and the hot summer sun would warp the instrument very much out of adjustment. The two casting alloys used by Gurley have been tested by the Bureau of Standards and found to have a coefficient of expansion of about 17½ parts per million per degree centigrade. The composition of the tubing and rod used has also been tested by the Bureau of Standards and reported in one of their bulletins as having a coefficient of expansion of 18 parts per million. Thus you will see that all of the structural elements have, for our purpose, identical coefficients of expansion.

It is also necessary that the material be such that it can be handled in the foundry without difficulty. Many of the castings are small and intricate with abrupt changes in section. And furthermore, they must show no flaws or blow holes when machined. It takes considerable experimenting with a new pattern to determine the proper location of gates, risers, and sprues for many castings, and it often becomes necessary to change the method of molding if the alloy or pouring temperature is changed, as well as when the design is changed.

Microphotographs of sections of the standard casting show quite a thicker grain structure under the riser than that of the opposite point at the top of the standards which was in the bottom of the

casting. The bottom cools more rapidly than the top, thus giving a finer structure.

The alloys are made by a reputable firm and cast into ingots. It is then only necessary for the melter to put the proper ingot into the pot. There is no chance for making a mistake in weighing up his ingredients. No scrap materials are ever used in the Gurley foundry. It is the practice to make a triple check on the analysis of the alloy used, by drillings taken when shipped, and upon receipt at the Gurley factory.

The principal factor of interest in connection with the various tubes used in a transit is the internal strain in the tube. A special study of these strains has been made by Gurley, and they are measured by a new method which we have named the "Strip Method."

A thin strip is milled in one side of the tube and then cut off at one end. If there is any longitudinal strain in the tube it will be shown by the bending of the strip, either outward or inward. Knowing the stiffness of this particular tube, it is easy to calculate the amount of the fibre stress. These samples show maximum stress amounting to approximately 8000 pounds per square inch.

Of course, it has long been known that by annealing brass tubing the strains may be removed, but this, of course, would make it useless for our purpose. The same annealing, for example at 300°C. (or 572°F.) makes the harder tube softer than the other after seven hours.

The same tubes heated at 250°C. have not been decreased in hardness. In fact, one of them is slightly harder after the heat treatment than before. Such treatment, however, if carried out to the proper length of time, will remove the internal strains, so that after the tubing is machined it will retain its shape. A special electric furnace has been built in the Gurley factory for this heat treating.

The temperature is automatically controlled, and recorded on a chart. If necessary, it may be kept to within plus or minus 2°F. of the desired temperature.

Heating a sample of No. 1 hard tubing for three hours at 350°C. makes little difference in its grain structure, which means that it has retained its original strength.

Heating a piece of No. 3A hard tubing for the same time changes it materially, as shown by the size of the crystals. It has been very greatly softened, making it useless for structural purposes.

This shows too that the proper heat treatment must be worked out for each kind of tubing, or, on the other hand, if the same heat treatment is to be given, all tubing must come from the mill with the same degree of hardness and the same amount of stress.

For routine factory practice it is sufficient to measure the Brinell hardness before and after heating to be sure the work has not been annealed. A special form of "baby" Brinell machine is used for this purpose.

In the castings we have a similar problem in attempting to remove the casting or cooling strains. Although the metallurgy of this problem is quite different from that of the tubing, experiments have shown that casting strains can be removed. When heated at 550°C. for one hour, 100 per cent of the strains are gone. At 500°C. it requires four hours to remove the strains, and as the temperature is reduced the time must be increased very greatly.

METHOD OF MANUFACTURE

Some of the problems of manufacturing are just as interesting and as difficult of solution as those of the metals. The job of the factory superintendent reduced to its simplest terms is to establish within the transit certain lines, right angles and perpendiculars. It is easy enough to get the lines in place, but to keep them there in spite of every day use and abuse is the goal of all surveying instrument manufacturers. No one understands completely what makes an instrument lose its adjustments, but, *if* the parts could be perfectly fitted and put together without strains, and *if* there are no internal strains in the pieces, and *if* the coefficient of expansion is the same, the instrument should stay in adjustment, *if* properly handled.

In order that the parts may go together without strain the holes must be exactly located, that is, to within less than 0.001 inch. To accomplish this it is necessary to have jigs. A jig is nothing but a strong case in which the parts being worked upon can be properly located and rigidly held. This case is fitted with steel bushings or holes through which the piece is drilled. Since there is a clearance of about only $\frac{1}{10}$ of a thousandth of an inch, the holes must necessarily be in the proper place. This method enables us to drill, say, the plate and standards, so that the holes will exactly line up when assembling the instrument. If you were to take apart a transit ten years old and examine it carefully, you would probably find that many of the screw holes had been filed out or scraped in order

to allow clearance for the screw, because the holes in the two neighboring pieces do not exactly match up.

What is said about jigs also applies to various other kinds of fixtures where the operations are not those of simple drilling. The standards, for instance, have a special fixture which will help to locate them on the milling machine when hobbing out the axis bearings.

Another class of special tools is that of gages. Not many years ago it was left to the workmen to take calipers and micrometers of various kinds and measure each piece as it came off the machine. Not only was there the possible error due to carelessness or mistake, but the limit of accuracy with which such a measurement can be made was, in many cases, outside the required tolerance.

One of the very accurate measuring jobs in making the transit is to turn the limb and verniers to the proper size. A flush pin gage which shows an error of $\frac{2}{10}$ of a thousandth or less is used to measure the limb diameter.

If the diameter of the limb should be slightly large, or small, or that of the vernier wrong, or if they are not set right, an error in reading will result just as if the graduating had been wrong.

Most people not familiar with the work have an idea that those parts made out of glass are hard to make. With the proper tools, however, there is no more difficulty in working glass than there is in forming a metal. Glass vials are made from a good grade of selected glass tubing, moved back and forth over a curved rod of some soft material with a mixture of water and carborundum constantly applied to the rubbing surface. The vial is slowly rotated on its axis at the same time, thus making the inside a barrel shape. One end is then entirely closed and the other drawn down to a small tip. Immersing this in the proper mixture of alcohol and ether and evacuating the vial allows it to fill, after which the other end can be sealed up and the vial closed. It is then put in paraffin, engraved and etched with hydrofluoric acid.

The sensitiveness of the vial depends upon the curvature to which the inside of the glass is ground, but its reliability depends upon the smoothness of the inside surface, the freedom from dirt and purity of the liquid. Each vial must be very carefully tested, not only to see that it has the right curvature, but also to see that this curvature is uniform from end to end, and that there are no rough spots in the vial which will cause the bubble to catch or jump.

Grinding of the lenses is also a comparatively easy proposition. After the formulae have been worked out, the glass for the objectives is obtained molded slightly oversize. These pieces are then cemented on blocks and rotated over a cast iron form of the proper curvature. First, a fairly course grade of carborundum and water is used until the proper shape is maintained, then successively finer grades of abrasives are used until the lenses are finally polished. The objective must consist of two pieces of different kinds of glass, in order that the different colored rays may be kept together. This makes what is known as an achromatic lens.

The skill of the lens manufacturer is shown by his ability to properly adjust the two pieces so that the lens is achromatic. This correction depends upon the spacing between the lenses and their relation to each other, as well as upon the selection of glass and curves. For this reason, an objective lens should never be taken out of its cell by the instrument man. If the lens becomes fogged so that it is necessary to take it apart, it is better to send it to the maker. If it should become necessary to take the lenses out of the setting, they should be put back in the same position. Marks on the edge of the lenses show how they should be located.

Workmen

But all of this study and care does no good unless the right kind of men are available to make the instruments. It is only with such men that we can feel sure after an instrument is once put together and sent to the shipping room, that everything inside of it is just as good as the outside, which may be observed. As a matter of fact, in many cases, more care will be taken on a part which is to be covered up, because of the fact that if anything were wrong it could not be seen after the instrument is put together.

Instrument makers must take pride in their work. Their loyalty cannot be replaced by any amount of skill in new men. The spirit of such men typifies the art of instrument making—for it is an art.

The care and thought given these instruments does not end when they are assembled. They must then go to the boxing room where each one is carefully packed in its own box. The spindle is held in place by a casting in the bottom of the box. Four tapered blocks or packing pieces covered with green felt are then placed in the sides of the box, so that they prevent the top plate from moving sideways. Two loose blocks are placed in the box at the ends of

the axis or bar, while two blocks in the cover come down on the top of the standards and are held very firmly by coiled springs. One end only of the telescope rests in a cradle and prevents any tendency to turn. An instrument thus packed should have all of the clamps loose, but will still be firmly supported in place. Any strains due to shaking are taken up by the packing pieces and not in the sockets or clamps of the transit.

In removing a transit from the box (or returning it to the box) the loose side pieces should first be removed and then the transit should be lifted by the top of the standards, not by the telescope or axis. It should then be placed directly upon the tripod without further action, and while holding in place with one hand, the bottom plate can be screwed on with the other. Much less time is required with this method in changing the transit from the box to the tripod, or vice versa.

The accuracy of results from using a transit depends to a large extent upon the stability of the tripod. Tripods are carefully measured for their stiffness or resistance to torque. This is done by applying a known twist or torque to the tripod by means of weights and a large radius drum, reading the deflection with the transit sighted upon the scale. The curves show the relative stiffness of the various tripods with the legs set up at different angles with the floor. An old Gurley mountain transit extension leg tripod, for instance, set very low, that is, with the legs making an angle of 45° with the floor, would twist seven and one-half minutes of angle under a given load, while the same tripod with the legs making angles of 70° with the floor would twist thirty minutes, or ½ degree, under the same load. The critical angle is 55° with the floor. This is quite a low position even for a short man. The common practice is more likely to be 65° or 70° than it is 55°. After considerable experimenting with different shapes of legs, heads and methods of attaching to the head, a new tripod has been developed which will twist only 2 minutes under the same torque mentioned above when set at 45° and 8 minutes at 70°. In other words, it is almost four times as stiff as the old mountain extension tripod.

These studies also showed the fact that most tripods when set up and given a strain or twist do not come back at once to the original settings, but change gradually over a period of several minutes, sometimes as much as one-half hour. This hysteresis effect common to most tripods has been completely eliminated in new designs without the addition of any appreciable amount of weight.

PUBLICITY AT THE WATER PLANT[1]

By Jack J. Hinman, Jr.[2]

Last year the Iowa Section had the pleasure of listening to Mr. Dow R. Gwinn of the Terre Haute Water Works Company and of hearing from him of the efforts which they have made to bring their water supply before the community that they serve. Mr. Gwinn is of the belief that it is eminently the proper thing for water officials to take the public into their confidence and in good faith to endeavor to see that they understand the problems of the plant, as well as the plant's advantages.

As a matter of experience it has been found that the community served by a water supply commonly holds an extreme view concerning that supply. This may be an attitude brought about by the actions of the present water officials or their predecessors. Mankind has an enormous inertia of opinion. When an opinion of a water supply is once established, it is very difficult to change it.

The usual attitude of the public about its water supply falls into two distinct types. Either the public is of the opinion that the supply is very bad, and that everything connected with it (rates included) are likewise bad; or else there is a fatuous sort of belief that the supply is the best that could be obtained anywhere. And, naturally, both attitudes are wrong.

Two statements are commonly made by the uninformed person who believes that the local supply is perfect or nearly so. One is that the supply is 99 per cent pure, and the other is that the supply is the best supply in the state and has been pronounced so officially by the Laboratories for the State Board of Health. I have heard these statements about several supplies this very week.

Now the statement that a water is 99 per cent pure has absolutely no meaning with regard to the satisfactory or unsatisfactory nature of a natural water. Water that contained 10,000 parts per million of foreign mineral and organic matter would still be 99 per cent pure.

[1] Presented before the Iowa Section meeting, October 24, 1923.

[2] Associate Professor of Sanitation and Chief, Water Laboratory Division, Iowa State Board of Health, University of Iowa, Iowa City.

But it is very likely that it would be undrinkable. On the other hand, water which contains a few typhoid bacteria, totaling much less than one part per million would carry disease and death into the homes of the most scattered patrons. Based on the actual percentage by weight of foreign matter even the vilest of our waters would come close to being passed as 99 per cent pure. But the important points are concerned primarily with the kind of foreign matter that the water contains—only secondarily with the quantity.

In order to pronounce a water supply the best in the state, one would have to know intimately all the water supplies of the state. He would have to know all about the history of each supply, its physical equipment, its distribution system, including by-passes and cross connections, the analyses of the supply, the characteristics of the operating personnel, and a lot of other things. No one man knows thoroughly all this about even one supply. The State Sanitary Engineer and the Chief of the Water Laboratory Division of the State Board of Health are constantly trying to get as much of these data as they can. But the data are exceedingly fragmentary in spite of their best efforts. And about the time that they think they understand about a supply, some changes are made and they find that they do not know quite everything about even that one supply. Moreover analyses are not made frequently enough to follow seasonal changes in the quality of waters, except in about 10 per cent of Iowa supplies.

I can speak with certainty for myself when I say that in my official capacity I have never stated that any one supply was the best in the state. To the best of my knowledge neither the present State Sanitary Engineer nor his predecessor ever made such a statement. None of us know which is the best supply in the state and we do not expect to know. It is enough for us that the supplies are maintained in safe condition at all times.

"Satisfactory at this time" is the best report that may be given upon a sample of water. A knowledge of the sanitary survey of the supply will give some idea as to how likely the supply is to remain satisfactory. Only the Supreme Grand Architect of the Universe can know if it will always remain a safe and wholesome source of the community's water, or what change the morrow will see.

What I wish to stress is the undesirability of a false public sense of security. Local officials are as likely as any one else to share the belief. The belief that all is well leads them to turn their attention

and to spend the moneys available for any betterments where they think the efforts and funds are more needed. That is good judgment, too, so far as it goes. But carried to its logical conclusion, it means lack of upkeep supplies, lack of repairs, and lack of programs for the extension of the water works system. It is apt to mean carelessness in following and understanding the changes in the quantity of water available until the town suddenly finds itself confronted by a water famine. Under such conditions there may develop a carelessness about the checking of the quality of the water, until the community learns that the water is unsafe and perhaps that there is an epidemic of water-borne disease among them.

On the other hand the unjustified condemnation of the supply may also cause serious trouble. The public judges a supply largely on the basis of temperature, taste and appearance. They seem instinctively to assume that the water is safe if they do not object to the appearance, taste or temperature. If they do not like the city water they commonly turn for their drinking supply to some private well and reserve for the city water the much less important duty of flushing. But the well supplies on private properties are usually worse than the city supplies—at least they are less closely watched and are more likely to be dangerous.

Not only does the public expose itself to danger in this way, but, believing that the supply does not justify further expenditure, there may be refusal to vote the funds necessary to proper extension or to accept rates which permit proper maintenance of plant and service.

The public ought to be informed correctly and honestly about its water supply needs. Apathy, suspicion, and ill-will sometimes must be overcome. This is a difficult task. It requires patience, resourcefulness and good faith. But it will pay dividends, both to the public and to the water officials if accomplished.

Old prejudices, founded in part on old controversies on other subjects, may interfere with water-treatment programs. Many people heard so much about alum being harmful in the old days of the baking powder controversies in the early history of the pure food and drug laws, that they feel that alum treatment of water surely must be fraught with danger. But alum in baking powder was largely fought from commercial standpoints. Besides such use of aluminum compounds is a different matter in fundamental details from water purification by alum, or more correctly, by sulphate of alumina.

Many people object to chlorine. There is no gainsaying that an overdose of chlorine will cause a taste, or that in the presence of gas house wastes such a taste may be accentuated, even when comparatively small chlorine dosage is applied. On the other hand there are examples of complaint of chlorine taste at times when no chlorine had been applied.

If the public knew the truth about water purification plant processes they would object less to what they so frequently call "doping the water with chemicals." Some idea of the nature of the chemicals used, their purpose and the amounts actually necessary would be helpful. It is easy to calculate and to weigh out for exhibit sample amounts of the solid chemicals necessary for treating 1000 gallons of water at the usual rate of application. Liquid chlorine for demonstration may be put up in glass tubes. There is a certain risk in handling it in such fragile containers, but the quantity liberated would be very small if the tube were dropped. I have used a tube of liquid chlorine that was put up for making Carrell-Dakin solution during the war. The quantities of the chemicals are apparently so small that this fact cannot help making an impression on the persons who see them. This is especially true if these persons are told how much material is recovered and removed in the process—or better still if a corresponding amount of the sludge is taken, dried and powdered. The eye can convey the conception of the quantities better than endless amounts of technical description and figures.

To a great many people a filter is a mysterious something that accomplishes purification by a kind of magic art. Cross section drawings of a filter, or a model, preferably a full sized one, can help the casual visitor to see what a filter really is and how it functions. Models always are to be preferred to drawings in dealing with the public. Many people cannot read the most simple blue-print. There are those who are at a loss to understand the more or less conventional details and they are totally unable to visualize a tank or filter from a drawing.

If a part of the mystery about coagulation, filtration and chlorination is cleared away, much of the prejudice will be removed. People are afraid of the things they do not understand, whether those things are water purification processes or the more solemn phenomena of life.

If a person can be made to understand what water purification actually accomplishes, there is a chance that he may appreciate it.

Charts of typhoid fever statistics are valuable for those who understand them, if there has been a very marked decrease in the incidence of the disease. But charts are of much more value for specialized audiences than they are for the general public, although explanations given orally to accompany the charts help greatly in getting the matter comprehended by all.

The first preliminary to convincing the public that the supply is good is to see that it *is* good. Sanitary defects should be sought out and corrected. If the solution of your difficulty is over your head or beyond your capacity do not be afraid to get expert help. It is cheaper in the long run.

When your plant is in good shape, see to it that the public has the opportunity to find that fact out. Externals frequently count for a great deal. If the plant is in a littered yard, and the floor of the pump room is oil-covered, even though the litter is clean material and the surface drainage is kept away from the water to be pumped, the public may be disgusted by the appearance. They do not distinguish between what may be described as different kinds of dirt. Neither does your operator discriminate, and, therefore, for you to tolerate litter, may lead him to tolerate filthy conditions.

Cleaning up the premises and parking the grounds are good preliminary measures. Then you are ready to devise methods for attracting the public, showing your wares, and in the current commercial language "selling" them.

Mr. Gwinn emphasized the value of keeping actively in touch with all civic welfare bodies, not only to take part as individuals in the program of betterments, but to learn or to anticipate the community needs, and to secure the support of the organizations for constructive sanitary and water supply programs.

Addresses to school classes, clubs and other organizations on water problems—not alone those of your own community—may awaken interest and stimulate intelligent inquiry and co-operation.

Exhibits at public meetings tell their stories more or less clearly. They are dependent upon the skill and thought used in planning the exhibit material. Moving figures or actual working models attract much better than photographs and signs. Simple things are always better than complicated ones.

One of the most successful examples of the use of publicity at the water plant is that of Grand Rapids, Michigan. Mr. Walter A. Sperry, then Superintendent of Filtration, devised the scheme. It

consisted of a predetermined route around the water works, with large, easily read signs at all points of interest. Models, charts, samples and other illustrative matter were placed at convenient points on the operating floor where they readily could be seen by visitors, but where they were out of the way of the filter operators.

Mr. Sperry arranged to give demonstrations, talks and excursions to the water plant for school children, club women, business men's organizations and others. By placing the water supply squarely before the people he was able to make the change from a well supply to a softened filtered river water supply, and to show the public that their supply was all that it should be.

Mr. Sperry developed a laboratory at the plant and demonstrated the value of it in all sorts of water works endeavor. He used the laboratory to convince the public of the care employed to furnish a safe and satisfactory water.

Mr. Sperry's methods have been imitated more or less at other plants, for instance at Benton Harbor in the new plant designed by Pearse, Greeley & Hansen.

An example of a public demonstration of a process in advance of bringing a water supply question and bond issue to a vote was given at Lansing, Michigan. The election has not yet been authorized on account of the need to augment the yield of the city wells. Lansing's supply has been a hard well water. The projected plant proposed to soften the water by the lime process. An old house near the business district was secured and a model plant was set up in it. The public was given an opportunity to compare the taste, washing properties, and appearance of the supply. The taste after treatment in the softening plant was very little altered, but the ease of producing a lather with soap was noticeably increased so that even the most careless person could hardly fail to appreciate the difference. The clarity of the water was improved and the water rendered sparkling and free from turbidity. Of course, almost any water works man would have expected this, but it must have been surprising to the public.

Besides the explanatory signs and marked route such as Mr. Sperry used, the Lansing demonstration plant operator was of course an exhibitor of his plant, ready to explain its operation to anyone who wanted further light on the methods.

ELECTROLYTIC PRODUCTION OF CHLORINE GAS[1]

By A. L. Goggins[2]

Although one of the most widely distributed elements known to chemists, chlorine is never found in the free condition in nature. It exists in enormous quantities in combination with sodium, potassium, magnesium and calcium. In combination with sodium, as sodium chloride, or common salt, it occurs in practically inexhaustible quantities. Scheele, a Swedish chemist discovered chlorine in 1774, but was unaware of the elemental nature of the new substance. Sir Humphrey Davy investigated and found chlorine to be an element in 1810.

Chlorine was first used as a bleach and later as a disinfectant, but, until the middle of the first century, disinfection was regarded as a process that prevented putrefaction. The thought of microorganisms was not associated with the process.

Spontaneous generation had been the explanation of the work now attributed to bacteria until 1862, when Pasteur proved the possibility of preparing sterile culture media and demonstrated the manner in which they could be protected from contamination. The big step in the study of bacteria did not occur until twenty years later in 1882, when Koch developed a solid culture media which permitted disinfectants and antiseptics to be studied quantitatively with a greater degree of accuracy than had been possible previously.

Chlorine in various forms had been used in treating sewage for a good many years before its value as an agent in water purification was appreciated. As an agent in water purification it has only been used since about 1905, but in the comparatively short time it has been in use we have all been convinced beyond doubt as to its value in the prevention of the spread of disease by water.

The problem now comes down to the question of the best and most reliable method and form in which to apply it. Free chlorine

[1] Presented before the Iowa Section meeting, November 6, 1924.

[2] Chemist in Charge of Filtration, Water Works, Topeka, Kansas.

now appears to be the best form in which to apply chlorine, but its handling and control have been difficult tasks.

Before using the electrolytic method for producing chlorine the writer had had experience with both automatic and manual control machines for the purpose of regulating the feed of chlorine, but his experience was not a pleasant one. Impurities in the chlorine continually clogged small valves and tubes, making cleaning a frequent necessity. Corroded parts frequently had to be replaced at considerable expense and no uniformity in control could be secured. Lack of control the writer thought was due partly to corroded and clogged valves and tubes and partly to the fact that the equipment was designed to measure volumes at given pressures and did not take into consideration temperature. A change in temperature must either cause a change in volume or pressure according to whether the pressure or volume remains constant. In either case, one of the two factors dealt with by the equipment must change, which would cause a variation in the feed of chlorine by weight, with a variation in temperature.

The trouble of cleaning and the cost of replacing worn-out parts could be tolerated, but the lack of control with such a sensitive process as chlorination, where too much gives trouble with taste and too little endangers the consumers life, seemed important to avoid.

The electrolytic cell was then chosen for trial to see if better control could not be secured. As early as 1893 the electrolytic cell was in use, but the earlier type of cell was used for the purpose of making hypochlorites. A current was passed through a saturated salt solution causing the salt or sodium chloride to break down into sodium and chlorine. The sodium then reacted with the water to form sodium hydrate, which combined with the chlorine to form sodium hypochlorite. This reaction was not complete. It was found that only half of the chlorine first formed combined with sodium hydrate for the formation of hypochlorite, the other half reforming sodium chloride. The secondary reactions thus set up caused the efficiency of the cell to be low and made it impracticable for use. The secondary reactions took place because there was no provision for separating the chlorine and sodium after they were once torn apart by the current. The old process was called the "non-diaphragm" process, while the new is a diaphragm process. The diaphragm process is the method by which the chlorine and

sodium can be separated, once they are torn apart. It is the principle of the Williams Electrolytic Cell.

The Williams cell consists of a concrete box rectangular in shape, its depth being its smallest dimension. The positive electrode is made up of graphite pins, suspended from the top of the cell, the negative electrode is formed by an iron wire screen at the bottom of the cell. The iron wire screen is separated from the brine in the cell by an asbestos diaphragm. Brine is then admitted to the cell through a small funnel at the tap. When the cell is filled with brine and the current turned on, chlorine, as gas, is liberated at the positive electrode, while the sodium is liberated at the negative electrode. The chlorine is drawn away from the cell as it is liberated and the caustic soda drops from the under side of the cell into a catch basin, thus preventing their contact and secondary reactions.

The quantity of chlorine produced depends only upon the amount of current passed through the brine, which can be regulated by an ammeter and rheostat to give the desired amount of chlorine.

The writer has found that the control of the cell is easy and more uniform results is attained than by the former method of control. It has also proven more economical than the former method of treatment. That it would be more economical in all cases, the writer does not care to say, but a few figures in regard to the requirements of the cell will enable each of you to figure for yourself.

The cell requires 15 amperes of current at not less than 2.28 volts flowing for twenty-four hours, to produce one pound of chlorine. The writer has found that it takes 4 pounds of salt to the pound of chlorine produced. No corrodible parts are used in the construction of the cell and there are no small tubing or valves to cause trouble by clogging. Hard rubber tubing, graphite, iron wire, concrete and asbestos are the materials used in the construction of the cell, which are cheap articles to replace should replacement be necessary. The only replacements that have been necessary at the Topeka filtration plant were the asbestos diaphragms about every two months, which may be changed in about fifteen minutes.

The caustic soda formed by the cell may be piped into the raw water and its value saved due to the fact that caustic soda is a water softener.

Earle Bernard Phelps in Water Supply Paper No. 229, U. S. Geological Survey, dealing with the disinfection of sewage and sewage filter effluents says "chlorine attacks the organic matter and the

bacteria simultaneously, but its effect on the former is a direct function of its concentration, while its germicidal effect does not bear such exact relation." If this is true for sewage it would also be true for water. This fact is embodied in the functioning of the Williams cell by mixing the chlorine with air before its application to the water, thus decreasing its concentration and thereby retarding its action towards the organic matter in the water and causing a longer contact period with the bacteria.

At various times questions have come up as to the effect of chlorine on the iron surfaces with which it comes in contact; whether the caustic soda produced was likely to cause damage to workmen as a result of the caustic action producing burns; whether there was liability of the cells exploding and whether or not the cell was an infringement upon patents.

The following is the report of a test made by the Kansas City Testing Laboratory concerning the effect that chlorine applied by the Williams cell process might have upon pipes and parts of machinery with which it might come in contact.

Two test rods, each ½-inch in diameter, were introduced into the side of a water main to a depth of about 6 inches. The water in this main flowed continuously in one direction and the chlorine was introduced into this main at a point between the two test rods. By this arrangement both test rods were subjected to exactly the same conditions except that rod 1 was immersed in the water before chlorination while rod 2 was immersed in the water after chlorination. The rods were of Bessemer steel.

The chlorine treatment used in this test is that of the regular chlorinating operation used at the Independence, Missouri pumping station. This test made at that place during the regular run for a period of two months was

Weight before test

	grams
Rod 1	144.0740
Rod 2	143.7345

Weight after one month's exposure

Rod 1	144.1820
(a gain of 0.1080 gram or 0.074 per cent)	
Rod 2	144.1745
(a gain of 0.4400 gram, or 0.31 per cent)	

Weight after two months' exposure

	grams
Rod 1	144.0722
(a loss of 0.1098 gram, or 0.01 per cent)	
Rod 2	144.2272
(a gain of 0.0527 gram, or 0.036 per cent)	

The gain in all these cases was due to the formation of a coating of iron oxide on the outsides of both test rods. It will be noted that rod 2, which was subjected to chlorinated water, gained most in weight during the first month. This, of course, is due to the formation of a greater amount of oxide. A point of great importance is to be noted from the fact that rod 2 gained only 0.0527 gram during the second month's exposure. This shows that the coating of iron oxide was acting as a protective coating and that, with a little more exposure, it would cease to form or, at least, would form no faster than one would expect from the natural disintegration of the pipe. This coating was strongly adherent.

Rod 1 showed a loss during the second month's exposure. This may be caused by the dropping off of some of the iron oxide which formed on it. This would leave the surface more exposed and oxidation would take place easily on these exposed surfaces. The oxide on this rod was not so firmly adherent as that on rod 2 and formed in spots, for the greater part, rather than over the entire surface. This report was signed by J. G. Hawthorne.

That any damage might happen to workmen because of caustic burns is improbable. The caustic soda is not handled in any way by the workmen and it seems unlikely and almost an impossibility that they would come in contact with it.

That the cell might explode is not predictable, but the writer has operated the cell now about a year and with no indication of an explosion.

When the cell was first installed at the Topeka Filtration plant; it was charged, by certain interests, that the cell and the process of its operation were infringements on one or more patents. This naturally caused a little uneasiness, but in view of the success of the cell, it was desired to continue its use and yet avoid any possible lawsuit. The Topeka Water Commissioner made a thorough and exhaustive investigation in connection with the matter. As a result of his investigations, he was convinced beyond any reasonable doubt that the employment of the cell was not an infringement of

any patent or patents and that they were entirely within their legal rights in using the same. Notwithstanding the charges of infringement, together with threats of suit, the use of the apparatus has been continued and no suits have yet been instituted. Their only conclusion is, therefore, that the charges of infringement were unwarranted.

CHARACTERISTIC PROPERTIES OF ZEOLITES FOR WATER SOFTENING[1]

By S. B. Applebaum[2]

Water softening by zeolites is finding a wide application. In certain industries as for instance, the textile industries and power laundries, hotels and individual house supplies, it has very distinct advantages over all other methods. For general boiler feed purification it is also rapidly reaching an equally prominent position. This success is due to the many advantages which the zeolite method offers, among which may be mentioned:

Complete removal of all hardness-forming constituents without after reactions.

Changes in the hardness of the water do not require adjustment of the softener or adjustment of the chemical dosage which was necessary for previous methods, such as lime-soda. The zeolites automatically take care of these fluctuations. The waste products of regeneration are liquid and may be introduced with impunity into any sewer; there are no slimes or solids such as lime sludge to be disposed of.

Zeolite softeners require only a small fraction of the space required by other systems, and may be operated under pressure, eliminating double pumping of the water to be softened. The process may be carried out in the cold and without change in the temperature of the water.

The hard water is generally passed directly through the zeolite, although in special cases it may be advisable or more economical to precede it by some preliminary treatment.

WHAT ARE ZEOLITES?

The term "zeolite" was originally a mineralogical term only. It is a name for a family of well defined hydrous silicates. The term is derived from a combination of two Greek words meaning "to boil" and "stone" and the name was given to this mineralogical

[1] Presented before the Chemical and Bacteriological Division, New York Convention, May 23, 1924.

[2] Assistant Technical Manager, The Permutit Company, New York, N. Y.

family, because when a blow pipe is applied most of the zeolites intumesce, i.e., swell or boil up in a characteristic way. Today the name "zeolite" is applied, not only to this family of minerals, but also to other substances which are not true minerals.

"ZEOLITES" AND "BASE-EXCHANGE SILICATES" ARE SYNONYMOUS

The base exchange silicates used today for water softening do not belong to the group of minerals classed as "zeolites" in mineralogy. The synonymous usage of these terms had its origin in the chemistry of soils.

In 1850 and 1852 J. Thomas Way, an English chemist, published two articles relating to experiments which he had made with soils. He found that soils possessed the power of separating bases from salts dissolved in water and that the combination of the soil with these bases "was rapid, if not instantaneous," similar to the reaction between an acid and a base. He assumed that there might be certain silicates in the soils to which this peculiar power was due and he proved the correctness of his assumption experimentally.

Eichhorn, in 1858, investigated certain mineralogical crystalline zeolites having a composition similar to the double silicates artificially prepared by Way, in order to determine whether they had the same properties. He made his experiments with the zeolites, chabazite and natrolite, and found that these minerals did have the same base separating properties as Way's double silicates, and in addition he found that the process could be reversed. This latter fact was unknown to Way, who had assumed that lime could replace sodium in the silicate, but that the lime taken up by the silicate could not be exchanged again for sodium. Later on, in 1871, Knop made similar experiments and found that the exchange properties were not limited to the hydrous *alumino* silicates. He produced hydrous *iron* silicates artificially which had the same properties as Way's alumino silicates and Eichhorn's mineralogical zeolites.

Since Eichhorn's discovery, it has become customary to call the base-exchange property a "zeolitic" property and to speak of the "zeolites of the soil," even though no appreciable quantity of crystalline zeolites has as yet been detected in the soil, to explain its power of exchange reaction.

No practical use was made of the base exchange properties of these silicates before the twentieth century. Then geologists began to attribute certain alterations of rocks to the reactions of

such silicates. And later Harm and Rumpler, two chemists, suggested the use of such base exchange silicates for the purification of sugar juices. Their experiments proved to be failures. Subsequently, Gans suggested the use of base exchange silicates for water softening purposes, and after considerable work he succeeded in developing the present zeolite method of water softening.

Base exchange silicates used in water softening are generally called "zeolites" following the usage of the word in soil chemistry, so that today the terms "zeolite" and "base exchange silicates" are used synonymously, irrespective of whether or not the zeolite used is a crystalline zeolite in the mineralogical sense or whether it is a non-crystalline alumino or iron silicate or a combination of both.

PREVIOUS ATTEMPTS AT CLASSIFICATION THAT HAVE FAILED

The various zeolites on the market today differ widely in appearance, and the claims put forward for their properties are equally at variance, but as yet no correct classification which corresponds to the actual properties of the various zeolites has been proposed.

Attempts have been made to classify the base exchange silicates into zeolites and non-zeolites, in a mineralogical sense, but nevertheless admitting that the non-zeolite possesses "zeolitic" properties. Such a classification, of course, is unjustified and only confuses, as long as the adjective "zeolitic" is used to describe the characteristic base exchange property of the substance.

An attempt was also made to classify zeolites into "natural" and "artificial" products. For practical purposes such a classification is of no value particularly, when the term "natural" is used for zeolites produced artificially under patent protection covering the process of manufacture as well as the "new" product manufactured.

Still other attempts have been made to classify zeolites into rapid acting and slow acting zeolites. Such a classification is misleading. As far back as 1852, Way found that the zeolitic action was "rapid and practically instantaneous." Of course, provision must be made that the substances which are intended to react have an opportunity to do so. It will be shown later that where such opportunity is provided there is no difference in the rapidity of action.

The chemical base exchange reaction which takes place in the

softening of water by the use of exchange silicates and in the regeneration of the exhausted silicates is always the same, irrespective of the kind of zeolites used, so that differences in the chemical composition are of no practical value as a basis of classification.

Nevertheless, the various zeolites on the market today do differ in their softening capacity, the time required to exhaust and to regenerate them completely and the amount of salt required to regenerate them. What characteristic property then can we discover which is present in unequal degree in the various zeolites used today, to serve as a basis to classify them and to explain why certain zeolites have greater capacity than others?

PROPOSED CLASSIFICATION

It will be shown that it is the arrangement of the contact surfaces of the zeolite grain which accounts for the differences in performance and explains the differences in:

a. Weight per cubic foot
b. Amount of water contained after drying at 105°C.
c. Total base exchange power
d. Time to exhaust completely and regenerate completely
e. Salt required for regeneration

ARRANGEMENT OF CONTACT SURFACES

All the zeolites used may be classified for practical purposes into two groups on the basis of their physical structure.

A. Porous zeolites
B. Practically non-porous or solid zeolites

The grains of the first group are filled, as the name implies with minute microscopic holes or passages of capillary proportions. These are not apparent to the naked eye, but are made readily visible by the application of a dye-stuff. The porous grain absorbs the dye, very much like blotting paper or a sponge, so that the entire granule both inside and outside becomes thoroughly saturated with the color.

To this first group belong the so-called "artificial" zeolites, whether made by fusing the ingredients together in a typical glass furnace and then hydrating and leaching or whether made by a precipitation process. Whether they contain aluminum or iron as a constituent is of no importance. The so-called "natural"

zeolites made from clay, that is passed through a series of artificial operations, such as shaping, burning and hydration, also belong to this porous group.

The grains of the second group are practically non-porous or solid. They do not absorb an appreciable amount of water into the interior of the grain. They are like tiny pebbles, and the contact of the water with the zeolite is practically restricted to their outside surfaces. To this second group belong the zeolites consisting of glauconitic substance.

HOW ARRANGEMENT OF CONTACT SURFACES AFFECTS OTHER PROPERTIES OF ZEOLITES

a. Weight per cubic foot

All zeolites have about the same specific gravity, 2.0 to 2.4.

But the zeolites of the first group by reason of their porosity weigh less per cubic foot than the more solid zeolites of the second group. The various porous zeolites when in a moist condition weigh from 55 pounds or even less, up to 70 pounds per cubic foot, according to their porosity. They contain water up to 50 per cent of the total weight.

The non-porous zeolites in a moist condition weigh about 100 pounds per cubic foot and the amount of water contained is generally below 10 per cent of the total weight.

The moisture content greatly affects the weight per unit of volume, but does not affect the volume itself. It is for that reason that purchasers should always insist on buying zeolite by volume rather than by weight.

b. Water of hydration

Zeolites are hydrous silicates, i.e., they contain water which cannot be driven off by heating them to a constant weight at 100 or 105°C. The water remaining at that temperature is often called water of hydration or water of constitution. The higher the amount of this residual water, the greater is the porosity of the zeolite and the greater the total exchange power of the zeolite.

c. Base exchange power between regeneration

The base exchange power between regenerations means the total number of grains of hardness, usually expressed as calcium carbonate, which a cubic foot of zeolite absorbs or exchanges up to the

point when "zero-hardness" water is no longer produced. This may be called the "softening capacity" of the zeolite and must not be confused with the "total exchange" power. When the softened water first begins to come through the softener with a little hardness in it, it is time to regenerate. That is the practical end-point of a softener's run, because the function of the zeolite softener is to produce nothing but "zero-hardness" water. But after this point is passed, the zeolite still has base-exchange power left and considerable additional water can pass through in a partially softened condition before the water emerges with the same hardness with which it entered.

The base-exchange power or water softening capacity is directly proportionate to the active surface of the zeolite in contact with the water. Since the porous zeolites have an active interior as well as an exterior surface, it would naturally be expected to have greater water softening capacity than the solid zeolites. The facts fulfill this expectation.

The softening capacity of a practically non-porous zeolite of about 0.5 mm. grain size is about 2500 to 3000 grains as $CaCO_3$ per cubic foot and with increasing porosity the capacity of the more porous zeolites increases to 10,000 grains as $CaCO_3$ per cubic foot and higher. These figures are average values influenced to some extent by the water composition, rate of softening and amount of salt employed in regeneration and rate of regeneration. This means from the practical point of view that the amount of solid zeolites must be larger, if they are expected to do the same work between regeneration as the porous ones.

RATE OF SOFTENING AND RATE OF REGENERATION

The higher water softening capacity between regenerations of the porous zeolites can only be obtained by bringing the interior surfaces into action. The internal active surface of the porous grains are harder to reach than the external surfaces of the solid granules. The grain of a porous zeolite may be compared to a capillary tube, whereas the solid zeolite may be represented by a solid rod. In order to make contact with or sweep over the inner surface of the capillary tube it is necessary to displace the liquid contained within. It is well known that capillary tubes hold liquid by adhesion against the force of gravity and time must elapse before the contents are displaced. On the other hand to pass the liquid over the external

surfaces of the solid rod or the outside surfaces of the capillary tubes takes comparatively little time. This holds true with the water softening reaction as well as the reverse reaction of regeneration. Likewise it is possible to utilize quickly the outside surfaces only of porous zeolites.

Usually the time employed to exhaust a bed of zeolite is six to twelve hours, depending upon the convenience of the local plant and the length of the labor shift. It is possible to exhaust the water softener capacity of the zeolite bed in as low as two hours without decreasing its capacity, but the greater amount of water used in washing and rinsing and the greater amount of labor required to regenerate the plant so frequently must be balanced against the lower cost of the smaller softener which a 2 hour run would permit.

During regeneration the brine must penetrate to the inner surfaces to bring out the calcium and magnesium previously removed and it takes more time and brine to do this than to brush by the external surfaces. Thus the solid zeolites and the outside surfaces of the porous zeolites can be regenerated in twenty to thirty minutes, whereas the interior surfaces of the porous zeolites may require one or more hours.

The porous zeolites are usually larger in grain size than the non-porous zeolites. This gives the latter somewhat more external surface area for the same volume of material. The smaller a sphere is the greater is the ratio of its surface area to its volume. But if the porous zeolites are reduced to the same grain size as the solid zeolite and only the external surfaces were called into action, both types of zeolites will act at the same rate and produce that amount of soft water which corresponds to their exterior surfaces. The delay in bringing the liquid in contact with interior surfaces causes the delay in utilizing them.

Thus all zeolites act instantaneously. It is not the stuff of which the solid zeolite is made or the way it is processed which makes it a "rapid-rate" material, it is merely the physical arrangement of the active reacting surfaces on the outside of the grain.

SALT REQUIREMENTS

Since, as explained above, the brine must overcome the adhesive power of the capillary passages of the porous zeolites, considerably more brine is used to accomplish a complete regeneration. If regenerated in the same way, the porous zeolites require about

twice as much salt per kilograin (1000 grains) removed, as the non-porous.

However, the brine that slips by unconsumed can be recovered and utilized again. This is the basis of the recovery method of regeneration which was invented several years ago. With this recovery method the porous zeolites can be regenerated with the same net amount of salt as the non-porous, namely, about ½ pound of salt per kilograin of hardness removed, expressed as $CaCO_3$.

FIELD OF APPLICATION OF THE POROUS AND NON-POROUS ZEOLITES

In general the porous zeolites are used advantageously for hard clear waters such as the waters on the Pacific coast or the well waters of the middle west. It is essential that the porous zeolites receive clear water because the inner passages must be kept clean and accessible. Mud or suspended matter in general would clog these passages up and then the porous zeolite would become non-porous.

Where no soft water is desired at night, and the whole night is therefore available for regeneration, rapidity of regeneration has no particular advantage and porous zeolite softeners may very well be used with convenience and economy in such cases.

The solid zeolites are adapted to waters of medium hardness that are not always crystal clear, such as the river and lake waters. These zeolites can handle slight amounts of turbidity without loss of efficiency, if sufficiently backwashed after each softening run, and only require clarifying filters to precede them if the hard water is muddy continuously.

Where rapidity of regeneration is important, the solid zeolites are to be preferred. For that reason household softeners should preferably contain this type of zeolite. The owner of a household softener wants the softener back on the house service lines just as soon as possible and a twenty to thirty minute regeneration, including the rinsing out of the brine, fits that condition very nicely.

Both types of zeolite have their field of application and equal success can be enjoyed with either porous or the solid zeolites, if they are utilized correctly.

EARLY HISTORY OF ZEOLITES[1]

By A. S. Behrman[2]

The commercial exploitation of the base-exchange process of water softening by means of zeolites, or certain hydrated double silicates, is such a comparatively recent development that many of us have assumed that the fundamental idea of base-exchange is equally new. A search of the literature discloses that the phenomenon of base-exchange by certain double silicates was well known before our Civil War.

The idea of base-exchange by double silicates was born in about 1850. I do not mean, of course, that this idea was the zeolite water softener as we know it today. Nor do I mean to detract in any way from the extremely creditable work done by a host of investigators since that time, not only in the theory of the mechanism of base-exchange, but in the development of the base-exchange substances themselves and in their industrial applications.

The father of the base-exchange idea was an Englishman, J. Thomas Way, Consulting Chemist to the Royal Agricultural Society. In 1850 and 1852 Way presented two classic papers[3] before the Society on the "Power of Soils to Absorb Manure." I can cheerfully and wholeheartedly recommend these two fascinating papers, totalling 86 printed pages, to any discouraged worker in chemistry.

The inspiration for Way's work was given by two agriculturist friends of his, Mr. Huxtable and Mr. Constable. Mr. Huxtable stated "that he had made an experiment in the filtration of liquid manure in his tanks through a bed of an ordinary loamy soil; and that after its passage through the filter bed, the urine was found to be deprived of colour and smell—in fact that it went in manure and came out water." This indicated the power of the soil to separate organic substances from solution.

[1] Presented before the Chemical and Bacteriological Division, New York Convention, May 23, 1924.

[2] Chief Chemist, International Filter Co., Chicago, Ill.

[3] Jour. Royal Agric. Soc. **11**, 313 (1850), and **13**, 123 (1852).

Mr. Thompson mentioned "that he had found that soils have the faculty of separating ammonia from its solution: a fact appearing still more extraordinary, inasmuch as there is no ordinary form of combination by which we could conceive ammonia to be combined in a state of insolubility in the soil."

Sounds like a problem in adsorption, doesn't it? It is a tribute to Way, that over seventy years ago, in practically entire innocence of physical chemistry as we know it today, he was able to abandon the idea of porous structure and to develop the workable hypothesis that certain cases of apparent adsorption were really cases of base-exchange.

It would be impossible to do full justice to Way's researches in the few minutes we can devote to them. But I would be cheating you out of a real pleasure, if I failed to point out very briefly his method of attack.

His first step in his study of the absorption of ammonia was to get away from the idea that the absorption was due to the porous structure of the soil. This he did by using other porous media without success. This led him to distinguish between absorption and what he called "chemical power."

His next observation was that this "power of the soil to combine with ammonia is greatly diminished by burning it." He showed that the loss of activity was not due to organic matter, by destroying the organic matter in unburned soil with nitric acid. He apparently missed the point that burning the soil dehydrated it.

Then came his important series of experiments in which he treated the soil with solutions of ammonium sulphate, and found in the filtrate "an abundance of sulphuric acid in combination with lime."

As the result of the experiments reported in his first paper, Way concluded that this power of base-exchange, or the "power to hold manure" as he termed it, was due to clay.

In his second paper he tried to isolate the particular and responsible constituent of the clay. He was satisfied that there was such, and he hoped to be able to produce it artificially. He did.

This responsible constituent was evidently a lime compound, since lime compounds always appeared in the filtrate. Since soils contain large quantities of silica, it was reasonable to suppose some calcium compound of silicic acid might be the substance sought. So he prepared calcium silicate by precipitation and tried it. The result was negative.

Thereupon, with rare persistence, he abandoned the idea of simple silicates, and turned his attention to the double silicates present in clay. He tried felspar, the double silicate of alumina and potash, and albite, the double silicate of alumina and soda. Again the results were negative.

In spite of this discouragement, he still persisted along this line. To use his own words, "it was still possible, however, that these double silicates, when formed artificially by precipitation, might be capable of effecting that which in the mineral state they were unable to accomplish."

So he made these "double silicates artificially . . . . by precipitation." For his experiments he prepared a double silicate formed by the action of sodium aluminate on sodium silicate. This product was the answer to his problem. The constituent of clay responsible for base-exchange—for "absorbing manure"—had been found.

It is almost unfair to leave Way and his experiments without even mentioning the wealth of other conclusions he drew from his researches. But most of these are of greater importance to agriculturists than to water purification technologists.

It would be unfair on the other hand, however, not to point out the one important flaw in Way's conclusions relating to base-exchange. He decided that there was a definite preference and order in base exchange and that, beyond this, the process was not reversible. He drew up a series of bases—soda, potash, lime, magnesia, and ammonia—much in the manner of the electromotive series of metals. In this series, any base would be dislodged by any one following it in the list, but the action would not be reversible.

We can forgive Way for this error. This was corrected a few years later by Eichhorn.[4] He showed that the bases were mutually exchangeable. He definitely established also the base-exchange properties of the natural zeolites, which are hydrated double silicates, and pointed out that Way's unsuccessful experiments with natural materials were due to the fact that he used anhydrous double silicates.

In Way's and Eichhorn's conclusions we have the essential theory of base-exchange as we use it today in water softening. We really have not advanced appreciably beyond this. It is true that a host

[4] Poggendorf Annalen der Physik u. Chem. 15, 126–133 (1858).

of investigators in the last fifty years or more have labored on the constitution of the zeolites, and particularly on the water of hydration, which exhibits several unusual characteristics. But the matter of constitution of the zeolites is of little interest to us here, unless we can connect this constitution and base-exchange. It is true, also, that the hypothesis has been proposed occasionally that the phenomenon of base-exchange is not really a base-exchange, as we ordinarily think of it, at all, but is a species of adsorption. While the theory of simple base-exchange introduces one or two conceptions that are unusual and, being unusual, are not clearly understood, the theory furnishes such a satisfactory working explanation that the burden of the proof is on the proponents of any other hypothesis.

The most important results of this work on the constitution of the zeolites, as far as we are concerned here, were the development of a great variety of ways for making the zeolites synthetically. The list is much too lengthy to be given here. Suffice to say, that by the end of the nineteenth century, there were synthetic precipitated zeolites, hydrated volcanic rock zeolites, hydrated aluminum silicate zeolites, and so many more that it is a tribute to the twentieth century chemist that he has been able to discover or invent any others.

The earliest suggestion as to the possible commercial or industrial application of the base-exchange power of the zeolites was made by Way himself, who thought that they might be used as fertilizers. This has never come to pass, with the possible exception of glauconite or greensand; and this is used as a fertilizer to a limited extent, more for its potash content, as such, than for the manner in which this potash is combined.

The first real attempt to utilize zeolitic materials industrially was in the beet sugar industry. The idea was that, if the potassium compounds in the sugar juices are replaced by calcium compounds, the yield of crystallizable sugars is materially increased. Credit for the idea of using the base-exchange power of the natural zeolite was claimed by Rümpler, though the first patent covering the process was issued to Harms.[5] Harms used as a base-exchange material a silicious earth.

A little later, Rümpler,[6] also working with the removal of potash from sugar juices demonstrated the base-exchange power of cement.

[5] Ger. Pat. No. 95,447, June 2, 1896.

[6] Die Deutsche Zuckerindustrie, 26, pp. 585 and 625 (1901).

He also carried out the purification by means of a synthetic material he precipitated in a porous medium like charcoal. Rümpler pointed out that if the zeolites were regenerated with sodium compounds, in place of calcium compounds, they would extract calcium, magnesium and potassium from solution.

If this paper is to be true to its title, it must stop here. The "early history" of zeolites ends with the opening years of the twentieth century. The fullness of the modern period is attested by the fact that the United States Patent Office has issued between fifty and sixty material, process, and apparatus patents relating to zeolites and their use.

The object of this brief paper has been to give this intense modern development its proper historical background.

DISCUSSION OF PRECEDING PAPERS ON ZEOLITES

MR. A. M. BUSWELL: I would like to ask if there are any data on porosity of any of the zeolites.

MR. S. B. APPLEBAUM: The relative porosity may be judged by the comparative weights per cubic foot, since the specific gravity of all zeolites is about the same. The paper states that the porous zeolites weigh about one-half as much per cubic foot as the non-porous.

I just want to say a brief word regarding the historical background. Way was the first to observe the base exchange property of zeolites but, as Mr. Behrman stated, Way did not know about regeneration or reversal of the base exchange. Furthermore, no one conceived the idea of applying zeolites to water softening until the twentieth century so that the history of zeolites, as far as water softening is concerned, started with the twentieth century.

MR. S. D. YODER: Mr. Applebaum in his introductory remarks relating to the uses of zeolite softeners makes certain statements as if they were well established facts, whereas these should probably have been given only as his opinion, for there is a great deal of reliable and contradictory evidence regarding some of these points.

It is essentially correct that zeolite softeners have replaced practically all other methods of softening water for hotels, apartment houses, laundries, textile and dyeing industries as used for their general purposes, but the statement that zeolite softeners are rapidly replacing the lime and soda softeners for treatment of boiler feed water is not borne out by the facts.

There are several fundamental objections to the use of zeolite water softeners for treatment of boiler feed water which prevent general adoption of zeolite water softeners for this service.

A very practical and fundamental objection to a zeolite softener for treatment of high carbonate waters is that the zeolite process leaves a large amount of sodium bicarbonate in the water, whereas this does not apply to the lime and soda process.

The sodium bicarbonate is broken down in the boiler to normal sodium carbonate, caustic soda and carbon dioxide. The carbon dioxide goes off with the steam and may in part be the cause of corrosion frequently reported where zeolite softeners are installed. The sodium carbonate and caustic soda rapidly concentrate in the boilers to cause priming of boilers unless high concentrations are prevented by excessive blowing down of boilers. It is always desirable in the operation of boilers to keep the sodium carbonate and sodium hydrate alkalinity of the boiler as low as possible and at the same time protect the boilers from scale and corrosion. This protection can be given by lime and soda softeners for lower excess alkalinity than can customarily be done with a zeolite water softener.

There is also some question as to what relationship the concentration of sodium carbonate and caustic soda in the boiler has to embrittlement of boiler plate. There is considerable evidence that points to high concentrations of caustic soda with respect to other sodium salts being a cause for embrittlement of boiler plate. Bulletin of Prof. S. W. Parr of the University of Illinois on the Embrittling Action of Sodium Hydroxide on Soft Steel refers to this subject.

With the present knowledge of embrittlement of boiler plate, its disastrous effects and its probable causes, the high alkalinities resulting from zeolite treatment of many waters will be a very important and practical objection to the general adoption of zeolite softeners for treatment of boiler feed water.

Mr. Applebaum's reference to "zero hardness" to imply that this signifies a complete removal of hardness or calcium and magnesium from the water, is open to question since it is based on the soap test.

The United States Government in its specifications covering zeolite water softeners does not rely upon the soap test for determining the extent of removal of calcium and magnesium required. It is customary for the Government to specify that zeolite softeners should have capacity for softening the required amount of water between regenerations so that the water leaving the softener will not have to exceed 10 to 12 parts per million hardness in terms of calcium carbonate. The United States Government is known to be exacting in its specifications, but it recognizes that it would not be practical to demand a complete removal of calcium and magnesium hardness as determined by chemical analysis.

Mr. Applebaum states that because of the varying amounts of

moisture that may be present in zeolites, a cubic foot is a better standard of value for zeolites than the pound. Whereas this is true, in view of his further statement that the exchange value of different zeolites varies from 2500 grains to 10000 or 12000 grains per cubic foot, it would seem that the cubic foot is also not a good standard to use. It would be well if zeolite softener manufacturers would use as a unit of standard an amount of zeolite capable of removing a definite amount of hardness from the water, as one grain per thousand gallons. Other standards might also be adopted, but it is evident that neither the cubic foot nor pound is a satisfactory unit of measurement.

MR. J. R. BAYLIS: I would like to ask if neutral sodium salts such as sodium sulphate have the same power of regeneration as sodium chloride.

MR. S. B. APPLEBAUM: Other neutral sodium salts will regenerate zeolites, but sodium chloride is the most economical.

In regard to Mr. Yoder's remarks, the zeolite plants themselves should be considered on the basis of total grains removed between regenerations. But if zeolite material is sold by the pound to an existing plant for additional capacity, and a certain number of pounds is shipped, the moisture dries out and the weight received is too low. The unit of volume will avoid this misunderstanding.

As regards the term "zero hardness," it is not a catch phrase. The soap test is a reliable test for zero hardness, has been used for determining hardness for many decades and is generally recognized and adopted for that purpose. The only precaution that has to be taken is the use of the correct strength of soap solution and the correct volume of water. We do not know where Mr. Yoder got the samples of the so-called zero water which he tested. They could not have been representative or the softener that he selected was either not properly designed or was very much over-run. It is conceded by almost everybody by this time that "zero" water is an actuality. See Hulbert's Special Bulletin No. 9, Vol. 5, pages 7 and 9, North Dakota Agricultural Experiment Station, for actual zero hardness results by the soda reagent hardness test.

The so-called disadvantages of the zeolite softened water for boiler feed purposes, namely: foaming and embrittlement, are not experienced by the actual user of zeolite plants. The impression

that zero water causes foaming has been created by a temporary condition that sometimes arises when heavily scaled boilers are fed with soft water which loosens the old scale. In such cases the boilers should be mechanically cleaned as much as possible before starting to use soft water and the loosened scale particles blown off at frequent intervals until the blowoff water is clear. If suspended particles and oily matter are absent, the water in the boiler becomes steady and with the usual blowoff there is no foaming. This has been the actual experience of all users of zeolite plants.

The "caustic embrittlement" theory was a suggestion made many years ago abroad. But it first came up actively in the United States about 1912. At that time in the University of Illinois there were some cracks in some of the boilers and a committee was appointed to investigate them. It was decided to have some research work done at the University. They took up the question with the boiler makers and agreed that nothing should be investigated as regards the fabrication of the boilers themselves, but only as to the water used. These investigations were made with pieces of wire in strong caustic soda solutions and the results were published in 1917. In the report, page 11, it is stated: "It is not in an attempt to explain the cause for boiler failures in these areas. Emphasis should be laid upon the fact that much more remains to be done before a complete and adequate explanation can be offered."

Nevertheless many references have been made to this paper with the understanding that it had completely solved the question.

Considerable work has been done abroad on the prevention of embrittlement in steam boilers, especially in England and Germany. An interesting report of a committee appeared as recently as 1923 in Germany. The central power stations using steam boilers had a great many cases of embrittlement after the war and organized a joint association with boiler inspection companies, boiler manufacturers and boiler plate mills to investigate the subject. After several years work they came to the conclusion that the underlying cause of embrittlement in the boiler seams is internal stress produced by the high riveting pressure in the boiler shop. If you take apart a seam that has cracked, you will find under the rivet head an indentation formed, that is, the rivet head has permanently deformed the plate. These permanent indentations indicate that a hydraulic riveting pressure has been used sufficiently great to exceed the elastic limit and actually to crush the plate, thereby setting up

high internal stresses. In other words, lower riveting pressure and the highest skill and technique in boiler fabrication is admitted by these German engineers to stop embrittlement. The boiler shops have there agreed to cut down the riveting pressures and put on their riveting machines a recorder which makes a record of how much pressure was applied and how long it was applied to each rivet. This account appeared in the proceedings of the V. D. I. 1923, which corresponds to our National A. S. M. E.

In a recent article in "Power," April, 1924, entitled "Action of Caustic Soda on Boiler Steel," a very old French experiment is repeated of passing an electric current through caustic solutions and collecting the hydrogen which penetrated through the steel. But the same amount of hydrogen would be collected if ordinary tap water is used without caustic soda (see the experiments of Fuller). Therefore, this paper does not in any way show that caustic soda is the cause of hydrogen embrittlement. The presence of caustic soda in cases of embrittlement is merely a coincidence. It is a fallacy to assume that because two things happen or occur simultaneously, these must necessarily be "cause and effect." Caustic soda occurs in nearly all boilers in greater or less degree so that in the same way one might blame all boiler troubles on caustic soda. Intercrystalline cracks can be produced by excessive internal stress in the absence of corrosive agents, but they are never produced in the absence of stress.

In over ten years of experience with the installation of zeolite plants for boiler feed purpose for thousands of boilers, the Permutit Company has not encountered a single case of embrittlement using Permutized water.

Therefore, the use of the term "caustic embrittlement" is unjustified and should be abandoned since it diverts attention from the underlying cause of cracks and creates an erroneous idea of the phenomenona in question.

MR. A. S. BEHRMAN: Mr. Applebaum's paper is very interesting; but he certainly is not justified, to my mind, in calmly dismissing as non-existent the two principal objections to the use of zeolite softening for boiler water, when the raw water contains even a moderately large amount of temporary hardness. Foaming with such water softened by the zeolite method is too frequent in occurrence and too well established by experience—even in boilers that have had all

trace of old scale removed long ago—to be thus calmly dismissed with a word as negligible. And caustic embrittlement is at this moment the subject of so much study and dispute, and the case is so far from being proven—either for or against—that it seems to me highly improper to attempt to close the case in the summary fashion Mr. Applebaum has done.

In a paper before the convention of this Association at Philadelphia in 1922 (c.f. JOURNAL *10*, 623 (1923), I pointed out the fundamental limitations of both lime soda and zeolite softeners; and I cannot help but feel that all manufacturers of water purification equipment should recognize not only the merits, but also the limitations, of their particular type of apparatus.

DISCUSSION

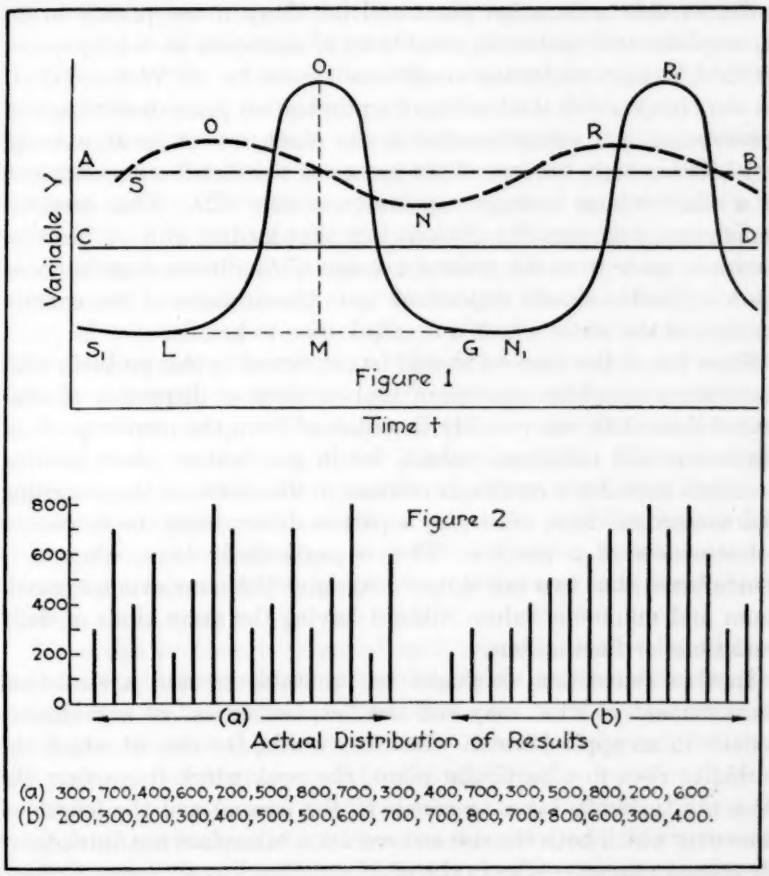
A STATISTICAL APPROACH TO THE PROBLEM OF DETERMINATION OF ALLOWABLE LOADINGS FOR PURIFICATION PROCESSES

A careful review of reports dealing with the loading of purification processes leaves the writer with the impression that an exceedingly difficult and intricate problem of interpretation of a large number of data is being attacked from the standpoint of opinion rather than of quantitative mathematical analysis. There are, of course, many opportunities for expression of opinion and demonstration of logic in many of the phases of purification loadings. It appears to the writer, however, that the real answer to the question: "What are the allowable densities of certain characteristics in water supplies beyond which the practicable processes of purification fall down?" lies in a detailed statistical analysis of the tens of thousands of data which are available in a large number of purification plants, in whose practical performance the definite answer, if there is one, should lie. The attempt to predicate quantitative limits, of whatever character, for purification plant loads upon personal "judgment," no matter how important the authority presenting that judgment may be, in contrast with a figure based upon a purely impersonal analysis of the historical "facts," may be doomed to failure when applied to actual practice.

One reason for the writer's pessimism as to the advantage of personal opinion over quantitative correlation by extended mathematical procedures lies in the fact that much of the personal opinion must necessarily be erroneous, or at least confused, when emanating from a cursory bird's-eye view of tens of thousands of figures scattered over a number of purification plants. Mathematical checking of such opinions in other fields has demonstrated, time and again, that the facts of the case frequently produce conclusions diametrically opposite to those derived from mere opinion. It will probably be admitted that it is no simple process to develop a conclusion from thirty thousand analyses in a single plant or to extend that hypothesis to several hundred thousand analyses covering a series of plants.

In view of these circumstances, it appears pertinent to point out

the directions in which future activity might be profitable. In most of the attempts to present quantitative limits for purification loadings, eminent practitioners, as well as novices, have been in the habit of clinging closely to the simplest measures of the characteristics of the raw water under discussion. For example, the allowable bacterial loading for water purification plants which is most frequently



quoted is 500 B. coli per 100 cc. In some instances there are added to this estimate additional values for maximum and minimum B. coli contents to give some closer idea of the importance of other facts. It is tacitly assumed by most workers that the average loading on a purification device is not a particularly good criterion of the weakness or strength of that device. In figure 1, for example, line *AB* in-

dicates the average density of, say, B coli in a raw water during a particular time interval, T, in a particular stream and CD the same average character in another raw water. The line AB represents the average of the B. coli determinations, the daily values of which are shown in the curve $SONRB$ and the average curve CD is presented in its daily fluctuation as curve $S^1O^1N^1R^1D$. Standard practice has indicated that a filtration plant will fall down more quickly in its accomplishments under the conditions of operation shown by curve $S^1O^1N^1R^1D$ than under the conditions known by $SONRB$. Yet, if we were to establish the loading of a purification plant on the basis of the average, AB, easily handled in one plant, we set up an average which is too high, because of the nature of the distributions resident in a plant whose average raw water is only CD. This analysis demonstrates at once the obvious fact that loading of a purification device is, aside from the general average of conditions superimposed upon it, fundamentally dependent upon the *variation* of the characteristics of the water which it is called upon to handle.

Since this is the case we should be concerned in this problem with some more complete measure of the variation or dispersion of analytical data than can possibly be obtained from the mere reports of maximum and minimum values, for in purification plant loading problems each day's results, in relation to the results of the preceding and succeeding days, must play a part in determining the success or defectiveness of a process. This is particularly true, when it is remembered that two raw waters may have the same average, maximum and minimum values without having the same kinds of daily variations or fluctuations.

In this connection, it might be profitable to add a statistical measurement of what may call the "explosiveness" of any characteristic in an applied water. In other words, the rate at which the turbidity rises in a particular plant, the peak which it reaches, the time the turbidity takes to recede to the normal and the length of time over which both the rise and recession take place are much more significant characteristics in the problem of loading than any average estimate of conditions might be. The correlation, therefore, of such measures of explosiveness, as for example $\frac{O^1M}{LM}$, $\frac{O^1M}{MG}$ and $\frac{O^1M}{LG}$ with a long-time series of treated waters would determine quantitatively what influences the mere "explosiveness" of an applied water has upon the character or quality of an effluent. The purification plant

operator would probably be willing to admit that it is sometimes more difficult to treat a stream whose average turbidity is low, but which shows high explosiveness values, than it is to treat a stream whose turbidity is consistently high, but which is not susceptible to sudden overturns of operating conditions.

In the use of such measuring devices as herein called for, however, the writer wishes to point out that existing statistical methods of measurement of dispersion or variation, such as the coefficient of variation and the standard deviation, do not distinguish between series (a) and series (b) in figure 2, as has been ably pointed out by W. L. Crum, a competent statistician. As Mr. Crum indicates, "these coefficients attach the same importance to a given difference between two variates which are widely separated and two which are adjacent. They indicate the extent of the fluctuation, but fail to account for its rate." Mr. Crum, therefore, proposes a new measure of variation which he terms the "fluctuation rate." This is not the time, of course, to enter into the details of the derivation of this statistical measure, but it is pointed out here to indicate another fallacy which the study of purification plant performance may lead us to, if we do not give due emphasis to the vast difference between the distributions shown in figure 2 as (a) and (b). Here, too, the conclusion which might be drawn from average, maximum and minimum values would give no real index to the actual operating difficulties which have been encountered and which must necessarily determine the load which a purification device may have been able to sustain.

When this problem is extended, as it necessarily must be, to more than a single characteristic, for the effects of turbidity, applied chemical, color, and other characteristics are mutually active in the regulation of allowable loadings, it is clear that dependence upon judgment, rather than upon extensive statistical calculation, is likely to lead to erroneous and possibly dangerous standards. Where the number of attributes involved is more than two, and this is the case with the question at hand, it is difficult to see how much progress can be made until we have recourse to the use of the coefficient of partial correlation. If we are to eliminate mathematically the effects of one attribute on the others it should be done by a close survey of the actual data by measurements susceptible to checking and independent of personal equation and not by round table discussion, where each person's judgment may be as good as any other's and none is com-

pletely valid without support by the quantitative evaluations of pertinent figures.

ABEL WOLMAN.[1]

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[1] Editor, Journal of the American Water Works Association. Chief Engineer, Maryland State Department of Health.

SOCIETY AFFAIRS

CALIFORNIA SECTION

The California Section met at the Sacramento Hotel, Sacramento, October 23, 24, 25, 1924.

The following major papers were presented:

Sacramento Filter Plant, by Charles Gilman Hyde.

Construction of Plant, by George J. Calder.

Mechanical and Electrical Appliances in Use at Filter Plant, by B. F. Raber.

Notes on Filter Plant Operation, by Harry Jenks.

What the American Water Works Association Means to the Waterworks Corporation or Department, by C. B. Jackson.

Water Resources of California, by Paul Bailey, Deputy Chief, Division of Engineering Investigation, Department of Public Works, State of Calif.

Control of Appropriations of Water by the State Division of Water Rights,[1] by Edward Hyatt, Jr. Chief, Division of Water Rights, Department of Public Works, State of California.

Relative Costs of Gravity and Pumped Supplies for City, by Wm. Hurlburt.

The Menace of Cross Connections in a Public Water Supply, by R. F. Goudy.

The following five minute papers were given:

Meter Shop Methods, by A. P. Lovell.

The U. S. Treasury Standards of Water for Interstate Carriers, by H. B. Hommon.

Water Treatment and Laboratory Control, by Wilfred F. Langelier.

Collection of Costs for External Damages to Water System,[2] by O. E. Clemens.

Billing and Collection Methods,[3] by E. R. Prentice.

After general discussion of the above, further discussion followed upon the following subjects:

[1] This Journal, page 125.

[2] Journal, January, 1924, page 39.

[3] Journal, January, 1924, page 42.

Corrosion of sealed services.

Methods of charging for installation of sealed services installed in advance of paving.

Treatment of surface storage to prevent algae growths.

Experience in contamination of low pressure steel water pipes adjoining vitrified clay service mains.

On Tuesday evening, following a dinner at the Sacramento Hotel, at which there were one hundred members and guests, the following officers were nominated by committee and were unanimously elected: George W. Pracy, Chairman; C. B. Jackson, Vice-chairman; P. Diederich, Member Executive Committee; John Burt, Member Executive Committee; S. B. Morris, Secretary and Treasurer.

The Secretary announced the loss of nine members by resignation and two by death. New members admitted during the year, 33, present total, 99.

	MEMBERSHIP BY YEARS			
	1922	1923	1924	Pending October 23, 1924
Honorary	0	1	1	0
Corporate	6	7	8	1
Active	60	65	83	5
Associate	3	4	7	1
Total	69	77	99	7

The remainder of the evening was given over to the presentation of papers by C. B. Jackson on "What the American Water Works Association means to the Water Works Corporation or Department" and by Paul Bailey on "Water Resources of California."

On Friday morning, in addition to the reading of papers, the following resolutions were passed. Upon motion of Wm. Hurlburt the following resolution prepared by George Read, was passed upon the death of Edward K. Wintz, member of this Association.

WHEREAS, an all-wise Providence on March 16, 1924, called from his active labors to his long rest, a fellow member of this Association:

Therefore, be it Resolved, That in the death of Edward K. Wintz, the California Section of the American Water Works Association has been deprived of an honest and efficient member; and this Association, as well as the City of Los Angeles, for which he worked in the Department of Public Service for many years, will suffer loss;

Be it further Resolved, That we deeply sympathize with the members of his bereaved family towards whom he was ever an affectionate husband and father, unselfishly mindful of their comfort and happiness;

Be it further Resolved, That this resolution be spread upon the minutes, and an engrossed copy of the same be forwarded to the members of the sorrowing family.

Upon motion of George H. Bragg of the Pacific Gas and Electric Company, the following resolution was passed upon the death of Joseph Warren Hall, member of this Association.

WHEREAS, on March 10, 1924, death took from us Mr. J. W. Hall who was an active member in our Association since June 7, 1907, and by his interest helped to enlarge the usefulness of our organization.

As Manager of the Stockton Water District of the Pacific Gas and Electric Company, he was capable, efficient, and thorough and was held in the highest esteem by everyone.

With his associates, he exhibited those qualities of fairness and uprightness which endeared him to each one. His genial personality and kindness attracted men to him and his opinions on all problems of the industry which he managed were accepted without question. Endowed with a brilliant mind, sterling integrity, and indomitable energy, his life has been a powerful influence for good.

We feel we have lost an esteemed friend and a wise counsellor and that his passing removes from our midst a truly good man.

Now, therefore, Be it Resolved, That the members of the California Section of the American Water Works Association, in meeting assembled, do express their sincere sorrow at the loss of so valuable an associate and friend.

Be it further Resolved, That this resolution be spread upon the minutes of our Association and a copy thereof over the signature of our President be transmitted to his family and also to the Pacific Gas and Electric Company.

On Friday evening a dinner dance was given to the members and guests at the Hotel Sacramento by the exhibitors, 181 members and guests being present. During the dinner hour vocal and instrumental music was enjoyed, followed by a delightful dance. During the dinner and dance, Mr. Dudley and the "Orpheus Four" quartet, through the courtesy of Mr. J. R. McWane, gave a delightful performance.

On Saturday the members and guests, including ladies, were entertained at luncheon at the Sacramento Filter Plant by the City of Sacramento through the courtesy of Mr. Botloff, City Manager and Mr. Prugh, Chairman of the Local Committee, Mr. Harry Jenks Superintendent of Filtration and Mr. Carl Haskinson, Chief Engineer of the Pumping Plant. Both before and after the turkey luncheon,

the party were taken through the entire filtration and pumping plants.

During the luncheon a few words were spoken by City Manager Botloff upon the successful operation of their filter plant and how its timely completion had enabled the City of Sacramento to furnish an adequate supply of water during the driest year of record and consequent reduction in quality of the raw water which could not possibly have been used without filtration.

Following an invitation from Mr. Pratchner, Commissioner of Public Works of the City of Santa Cruz, the Convention voted to hold the Sixth Annual Convention in that City during the fall of 1925.

Charles Gilman Hyde presented a very thoughtful motion seconded by C. B. Jackson and carried by a rising vote, thanking Mr. Prugh and the Local Committee, Mr. J. R. Barker and the Exhibitors Committee, The Sacramento Hotel, Mayor Elkus, City Manager Botloff, and all others who so ably provided the comfort and entertainment of members and guests.

C. B. Jackson, newly elected vice-president of the Association, presented a motion eulogizing retiring President Fred H. Klaus for his most effective and efficient handling of the affairs of the local section for the past year.

During the convention, the thirty lady guests were entertained by the local committee on Thursday evening at a theatre party and on Friday afternoon by an automobile trip about the City of Sacramento. Friday evening and Saturday the ladies enjoyed the entertainment with the members.

There were registered during the Convention 167 members and guests and 30 ladies, making a total of 197 present.

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

High Pressures and Temperatures in Central Stations. W. S. MONROE. Power, 60: 3, 87, July 15, 1924. Discusses reheating and regenerative cycles: shows why initial cost with 550 or 600 pounds need be but little more than with 300 pounds pressure.—*Aug. G. Nolte.*

Effect of Oil Pollution of Coast and Other Waters on the Public Health. F. W. LANE AND COMMITTEE. Public Health Reports, 39: 28, 1657, July 11, 1924. Paper is one of appendices of more comprehensive report of investigation made recently on this subject by Bureau of Mines in coöperation with American Petroleum Institute and American Steamship Owners' Association. Health menace of oil lies in fact that it renders marine food unfit to eat, injures the beaches, discourages fishing, boating, and hunting, possibly retards normal oxidation of sewage, and may result in irritations or skin diseases. For definite conclusions more work must be done on subject.—*Aug. G. Nolte.*

Power Plant Exhibits at Wembley. J. B. C. KERSHAW. Power, 60: 4, 131, July 22, 1924. Some of the exhibits covering boiler room equipment, shown at British Empire Exposition, are illustrated and described.—*Aug. G. Nolte.*

Furnace Linings. G. B. RANDALL. Power, 60: 4, 146, July 22, 1924. Discusses use of ground brick bat mixture for lining. Best results obtained by using 70 per cent ground brick, 25 per cent fire clay and 5 per cent burned silica.—*Aug. G. Nolte.*

Internal-Combustion Engines at the British Empire Exposition J. B. C. KERSHAW. Power, 60: 5, 168, July 29, 1924. Various types of engines are illustrated and briefly described.—*Aug. G. Nolte.*

How to Determine the Proper Size of Chimney. T. S. CLARK. Power, 60: 5, 175, July 29, 1924. Factors to be considered in designing chimneys for various installations are discussed. Examples are stated and computations made.—*Aug. G. Nolte.*

Oil Systems Specially Designed for Municipal Pumping Plant. H. R. CADY. Power, **60:** 6, 203, August 5, 1924. Oil is supplied by overhead tanks to all bearings and gears at Queen Lane Station in Philadelphia. Gravity tank provides 15 minute supply without return pump. Operation checked by indicating devices.—*Aug. G. Nolte.*

Modern Equipment Reduces Cost of Power. Power, **60:** 6, 210, August 5, 1924. Municipal Lighting Plant of Abbeville, La., replaces steam equipment by Diesels. Cost of generating current reduced 40 per cent. Water Works served by motor driven centrifugal pumps and air lift. Comparative cost data given.—*Aug. G. Nolte.*

Pneumatic Conveying of Pulverized Coal—Blow Tank Method. I. G. COUTANT. Power, **60:** 6, 215, August 5, 1924. Operation of this method is illustrated and described.—*Aug. G. Nolte.*

Fuel Oils for Diesel Engines. D. AUFHAEUSER. Power, **60:** 6, 231, August 5, 1924. Extracted from "Zeitschrift des Vereines Deutscher Ingenieure" March 1, 1924. Properties of diesel oils are functions of their degree of distillation. Combustion is merely a fractional distillation. Present method of determining flash-point is valueless as guide in Diesel Engine operation.—*Aug. G. Nolte.*

What a Charge of Salt Solution Looks Like after Travelling 18,000 Feet in a Pipe Line. E. A. TAYLOR. Power, **60:** 7, 244, August 12, 1924. Behavior of charge of salt water passing through long pipe, in salt-velocity method of water measurement, is illustrated and described.—*Aug. G. Nolte.*

Checking Switchboard-Instrument Connections. R. BROWN. Power, **60:** 7, 253, August 12, 1924.—*Aug. G. Nolte.*

Study of Indicator Diagrams made Easy. E. R. BENEDEK. Power, **60:** 7, 255, August 12, 1924. Simple method of diagram analysis is outlined.—*Aug. G. Nolte.*

Questions and Answers. FRANKLIN VANWINKLE. Power. In following volumes as designated questions are asked and answers given on following subjects—**60:** 3, 89, July 15, 1924. Vertical Circulation Space Between Fire Tubes; Weight of Coal in Storage Pile; Hunting of Shaft Governor; Exhaust Lead of Slide Valve; Loss of Economy from Generation and Use of Wet Steam; Interlocks on Elevators; Engine-Cylinder Lubricator; Advantages of Four-valve Engines. **60:** 4, 149, July 22, 1924. Beading of Tube Ends of H. R. T. Boilers; Location of Fusible Plug; Pounding of Duplex Pump; Voltage Between Leads and Reversing Rotation of Motors; Throttling Calorimeter. **60:** 5, 189, July 29, 1924. Mud in Steam Line; Fitting New Corliss Engine Valves; Removing Oil from Boiler; Determining Erosion of Turbine Blading; Strength of Furnace Sheets of Vertical Fire Tube Boiler; Noise from Small Direct-Connected Centrifugal Pump; Concreting Around

Engine Foundation Bolts; Irregularities of Diagrams Due to Inertia of Indicator; Relative Current Consumed by Single- and Three-Phase Motors. **60:** 6, 226, August 5, 1924. Indirect Radiation; Distribution of Exhaust for Warming Buildings; Obtaining Engine Friction Diagrams; Double Stop-valves on Boiler Connections; Obtaining Compression in Single Eccentric Corliss Engine; Cleaning Water Gauge Glass Without Removing it From Fixtures; Movement of Engine-Frame not Preventable by Compression; Sizes of Pump Suction and Discharge Lines; Drop Leg for Receiving Water in Excess of Separator Capacity; Safety Valve for Closed Heater. **60:** 7, 264, August 12, 1924. Use of Superheated Steam for Reciprocating Engines; Relative Length of the Water and Steam Cylinders of Direct Acting Steam Pumps; Rumbling Safety Valve; Protection of Blowoff Pipe; Effect of Throttling or Wiredrawing; Speed of Synchronous Motor Driven Clock on Curve Drawing Meter.—*Aug. G. Nolte.*

Resistance to Corrosion of Various Types of Chromium Steels. H. S. Rawdon and A. I. Krynitsky. Chem. Met. Ang., **27:** 171–3, 1922. From Chem. Abst., **16:** 3460, October 20, 1922. Pure chromium steels observed during immersion in dilute hydrochloric acid and in aerated distilled water. Pure iron and steels of low chromium content are much more resistant to to hydrochloric acid than those containing considerable chromium. Steels containing considerable nickel were more resistant to acid. For resisting corrosion by water and air high chromium content is necessary. Presence of large amount of silicon may aid greatly in resisting "weather" corrosion. It is noted that relative resistance of steel to hydrochloric acid test is not necessarily criterion of its behavior toward atmospheric corrosion.—*R. E. Thompson.*

The Corrosion of Iron. J. Newton Friend. (Carnegie Scholarship Memoirs, Vol. XI.) London S. W. 1.: Iron and Steel Institute, 28 Victories St. 161 pp. From Chem. Abst., **16:** 3462, October 20, 1922.—*R. E. Thompson.*

The Electrical Conductivity and Residue of Natural Waters. Reinaldo Vanossi. Anales soc. quim. Argentina, **10:** 21–33, 1922. From Chem. Abst., **16:** 3520, October 20, 1922. Large number of tests of well and river waters showed that electrical conductivity and total solids (dried at 105°) correlated closely when latter ranged from 0.1 to 2 grams per liter.—*R. E. Thompson.*

Active Carbonic Acid and the Hydrogen-ion Concentration in Water Investigations. Reply to J. Tillmans. I. M. Kolthoff. Z. Nahr. Genussm., **43:** 184–92, 1922; cf. C. A. **16:** 773. From Chem. Abst., **16:** 3519, October 20, 1922. Calculated values for carbonic acid in equilibrium with calcium carbonate and bicarbonate agree with experimental results of Tillmans and Heublein up to HCO_3^- concentration of 5 milli-equivalents per liter when solubility product is taken as 1.2×10^{-8}, while above this concentration, agreeing results are obtained by using value 1.6×10^{-10}. Table and graph given in original, showing amount of free carbon dioxide in equilibrium

with different amounts of HCO_3^- and calcium. Redetermination of solubility and pH value of saturated calcium carbonate solution gave values of 16 milligrams per liter and 10.2, respectively. Bromocresol purple was employed as indicator for range 6.0–6.8.—*R. E. Thompson.*

A New Method of Qualitative Bacteriological Analysis of Water. ANDRE PHILIBERT AND GEORGE MATHIEU. Compt. rend. soc. biol., **86:** 1004, 1922; Bull. intern. office d'hyg. publ., **14:** 738, 1922. From Chem. Abst., **16:** 3520, October 20, 1922. One hundred cubic centimeters of water are added to 100 cc. sterile 6 per cent peptone water containing 3.4 per cent phenol, and 2 cc. sterile lead subacetate solution ($\frac{1}{10}$ French codex strength) added to mixture, which is then distributed into sterile tubes as follows: 18 tubes of 10 cc., and one tube each of 8, 6, 4, and 2 cc., approximately equal to 5, 4, 3, 2, and 1 cc. of original water. Incubate 48 hours at 41°. Tubes showing brown color or blackish precipitate contain putrefying organisms. Test all tubes for indole. Transplant from tubes showing blackening to condensation water of tubes of litmus lactose agar. (1) Indole alone, B. coli; (2) blackened medium, no indole, paratyphoid B, etc.; (3) blackened medium, indole formed, red colonies on litmus lactose agar, putrid B. coli; (4) blackened medium, indole present, litmus lactose agar blue free-growing colonies, B. proteus.—*R. E. Thompson.*

Quick Hardening Cement for Wells. F. W. HUBER. Oil and Gas J., **21:** 13, 14, 1922. From Chem. Abst., **16:** 3537, October 20, 1922. Tests show that hydration of tri-calcium silicate in portland cement may be accelerated by suitable catalyst, hastening "setting." Product is superior to cement without catalyst.—*R. E. Thompson.*

Distillation Apparatus for Producing Make-Up Feed Water. WERNER HEINRICHS. Archiv Warmewirtschaft, **3:** 113–4, 1922. From Chem. Abst., **16:** 3520, October 20, 1922. Use of many effects for this purpose not economical, as residual heat in steam can be employed to heat feed water. Triple-effect apparatus illustrated and described in original.—*R. E. Thompson.*

A New Type of Water Tap. Municipal Engineering, **73:** 245, March 6, 1924. New type of tap, removal of which operates valve completely shutting off water supply, facilitating renewal of washers, described and illustrated.—*R. E. Thompson.*

Absorption of Atmospheric Gases by Water. J. H. COSTE. Analyst, **48:** 433–5, 1923. From Chem. Abst., **17:** 3900, December 10, 1923. Graph, for dissolved oxygen and atmospheric nitrogen, consisting of series of isothermal curves showing as ordinates volume of oxygen at normal temperature and pressure in 1 liter of water of any salinity, given in original.—*R. E. Thompson.*

Ammoniacal Liquor for Softening Water. M. CHEVALET. Soc. Tech. du Gaz; Gas J., **163:** 735, 1923. From Chem. Abst., **17:** 3900, December 10, 1922. Water used for gas washing or feed water can be freed of calcium carbonate

by addition of ammoniacal liquor, either to cold water or to feed water heater. In latter case at temperature of about 60°, the ammonia can be regenerated and used repeatedly. Process is cheap, simple of control, and offers possibility of replacing soda ash in processes employing latter.—*R. E. Thompson.*

B. Coli in Water in Relation to Health. W. H. Frost. Nation's Health, **5**: 527–8, 1923. From Chem. Abst., **17**: 3900, December 10, 1923. Presence of true B. coli demonstrates beyond reasonable doubt that water is polluted with fecal matter but does not prove water to be infectious. Sanitary surveys are valuable indicators of possibility of infection but epidemiological evidence is needed to establish and measure actual danger of water.—*R. E. Thompson.*

The Relation of Sewage Disposal to Water Supply. Jack J. Hinman, Jr. Bulletin 64, Engineering Extension Dept., Iowa State College, May 7, 1924. 11 pp. Dangers to sanitary quality of water supplies are reviewed and methods of avoiding discussed. For a supply to be continually dangerous, it must receive contamination constantly, or at relatively frequent intervals. It has been estimated that 0.1 per cent of the population excrete typhoid bacillus. Prohibition of cross connections is urged. If use of both private and municipal supply is desired, an elevated tank should be erected with municipal supply inlet at higher level than overflow outlet. Water supply conditions in Iowa are briefly summarized and urgent need for increased protection of water supplies against sewage contamination, dwelt upon.—*R. E. Thompson.*

Summary of Official Swiss Laboratory Reports for 1922. J. Pritzker. Schweiz. Apoth. Ztg., **61**: 495–9, 506–9, 1923. From Chem. Abst., **18**: 302, January 20, 1924. Analysis of tap water from galvanized iron pipes at Basel showed up to 2.5 grams zinc per cubic meter; while that passed through galvanized household boilers, potassium carbonate being added, showed maximum of only 0.6 gram zinc. Sample of old boiler scale contained 4.65 per cent zinc.—*R. E. Thompson.*

Poor Plant Management. Robert June. Blast Furnace Steel Plant, **11**: 546–50, 1923. From Chem. Abst., **18**: 318, January 20, 1924. Treatise on efficient combustion practice, combustion losses, and methods of minimizing them.—*R. E. Thompson.*

Waterproofing Concrete. F. Hartgrove. Brit. 200,564, Apr. 10, 1922. From Chem. Abst., **18**: 316, January 20, 1924. Waterproofing dressing for concrete consists of white copperas, glue, and water, preferred proportions being 1 pound each of white copperas and glue to 1 gallon water.—*R. E. Thompson.*

The Preparation of Non-Rusting Iron. W. Groume-Grjmailo. L'Oural 1922, No. 1, 11–2; Rev. metal., **20**: (Extraits), 454, 1923. From Chem. Abst., **18**: 217, January 20, 1924. Cast iron, even prepared from very pure ore, is

generally less resistant than puddled iron, unless prepared so as to eliminate liquation. Means of accomplishing this described, following which corrosion is prevented by formation of thin compact layer of rust.—*R. E. Thompson.*

The Addition of Sodium Carbonate Before Estimating Free Ammonia in Waters. A. W. KNAPP. Analyst, **48**: 486, 1923. From Chem. Abst., **18**: 301, January 20, 1924. When 0.1 mg. ammonium chloride was added to 500 cc. of water, all the ammonia was obtained by simply boiling and same was true when ammonium acetate was added, although the solution was acid to methyl orange. Addition of 0.5 cc. of 0.1 N. lactic acid prevented recovery of any ammonia by mere boiling, but all was obtained upon adding sodium carbonate.—*R. E. Thompson.*

A Rapid and Safe Method of Purifying Drinking Water. C. A. GRAU. Anales asoc. quim. Argentina, **11**: 82–5, 1923. From Chem. Abst., **18**: 301, January 20, 1924. To each liter of water add 5 drops 8 per cent tincture of iodine, followed 20 min. later by same amount of 15 per cent sodium thiosulphate solution. The products of reaction are harmless. Cf. this J., **11**: 9, 939.—*R. E. Thompson.*

New Water Tester for Steam Boiler Operation. R. KATTWINKEL. Wärme and Kälte Tech., **25**: 36, 1923. From Chem. Abst., **18**: 302, January 20, 1924. Compact portable set for determination of hardness, alkalinity, chlorine, oxygen, carbon dioxide, and iron, described.—*R. E. Thompson.*

South Staffordshire Water Works. FRED J. DIXON. Water and Water Eng., **26**: 271, July 21, 1924. Water supplied is ground water. There are 15 primary pumping stations and 7 secondary (or booster) pumping stations, 18 impounding and service reservoirs. Part of water is filtered for removal of iron bacteria.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Flow of Fluids in Pipe Bends. J. EUSTACE. Water and Water Eng., **26**: 270–1, July 21, 1924. Experiments on stream line motion in curved glass pipes and elbows by means of filaments of colored water introduced at various points in the cross section showed that there is no simple method of computing the loss of head due to curvature of pipes and pipe bends.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Bristol Water Works—Cheddar Supply. A. McC. PATTERSON, Water and Water Eng., **26**: 268–7, July 21, 1924. A standby supply formed by impounding stream formed in gorge by spring water. Control of stream from source to site of plant 1 mile below assured by purchase of property. Pumping station 6 mgd. Engineering cost data.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Decay of Reinforced Concrete and Timber in the Sea. ERNEST LATHAM. Water and Water Eng., **26**: 265–8, July 21, 1924. Information on subject is unsatisfactory. Apparently decay of skeleton reinforced concrete struc-

tures begins in less than 20 years. Results on timber are also conflicting. No one can tell whether decay of timber piles will occur in 10 or in 50 years. —*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Study of River Characteristics. HENRI LANG. Annales des ponts et chaussees, Mar.-Apr., 1924, pages 197-208; Water and Water Eng., 26: 291, July 21, 1924. Study made on the Seine and divided into two parts; (1) Control of rivers; (2) Methods of determining characteristics of a natural river. Natural slopes and gradient of bed should be retained when deepening a river. This study will not give indications of future flood levels because of uncertainty regarding form of flood waves.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Protection of Dams. O. POMINI. Il Monitore Tecnico, 87-8, Mar. 20, 1924. Water and Water Eng., 26: 292, July 21, 1924. Differences in stresses due to variation in temperature of order of 5°C. between upper and lower faces of dams is believed to introduce danger. Recommended that intercepting wall or thick facing on down-stream side of dam, with butresses built for tangential, and not longitudinal, pressure, be part of design.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Method of Constructing Concrete Dam in Zero Temperature. GEO. H. KOHL. Contract Record and Eng. Review, Eng. Contrg., 62: 364-7, 1924. Details construction plant, forms, and provisions for heating for executing work at 50°F. below zero.—*Langdon Pearse.*

Removing Odor from Water by Chemicals. 1923 Report, Gd. Pub. Service Comm., Los Angeles; Eng. Contrg., 62: 60, 1924. To remove odors in stagnant lower water of reservoir ammonium persulphate (2 parts per million) was tried, also 4 pounds per million gallons potassium permanganate. Condition cured by altering intake to use top water.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Application of Electrical Machinery in Water Works. F. C. BOLTON. Eng. Contrg., 62: 68-73, 1924.—*Langdon Pearse.*

Electric Thawing of Water Services. J. W. TURNER. Eng. Contrg., 62: 58, 1924. Describes one man equipment, easily built, thawing pipes at cost of $5.50 per thaw.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Service and Consumption Charges. New York Interurban Water Co. Circular. Eng. Contrg., 61: 1313, 1924. Circular sent out to explain services and charges.—*Langdon Pearse.*

Depreciation Rate for Water Works Structures and Equipment. Water Commrs. 50th Ann. Rep. Springfield, Mass., Eng. Contrg., 61: 1309, 1924.—*Langdon Pearse.*

Handling the Water Consumer. O. H. BISSELL. S. E. W. W. Assn., 1924; Eng. Contrg., 62: 347–9, 1924.—*Landgon Pearse.*

Increasing Flow of Wells by Shooting. C. W. VARNER. Ill. Soc. Engr.; Eng. Contrg., 61: 1090–1, 1924. Recommends shooting wells in St. Peter or Potsdam sandstone, in several places from 40 to 50 feet apart.—*Langdon Pearse.*

Iodine Treatment of City Water at Sault Ste Marie, Mich. H. A. SHERMAN. City Manager Magazine, December, 1923; Eng. Contrg., 61: 381, 1924. For 3 million gallons per 24 hours 2 pounds of sodium iodide were used, daily, for 2 weeks.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Mechanical Filtration Plant, Lanzon, Que. H. G. HUNTER. Can. Engr., 46: 279–80, 1924. Plant taking water from St. Lawrence R., with 1 million gallon daily capacity.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Water Works Pumping Plant at Guelph. H. S. NICKLIN. Can. Engr., 46: 267–8, 1924.—*Langdon Pearse.*

The New Water Supply System of Memphis, Tenn. F. G. CUNNINGHAM. Ind. San. & W. S. Assn., 1924, Eng. Contrg., 61: 773–80, 1924. Well water supply containing Fe and CO_2 is to be lifted by air lift, aerated and filtered. Details are given.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Stopping Reservoir Leaks with Lead Wool. Eng. Contrg., 61: 82, 1924. Calking cracks with lead wool proved effective.—*Langdon Pearse.*

Results of Cleaning Water Mains at New Albany, Ind. J. O. ENDRIES. Ind. San. & W. S. Assn., 1924; Eng. Contrg., 61: 793–6, 1924. Efficiency of forty-eight year old pipe was increased by cleaning.—*Langdon Pearse.*

Pipe Lines on Bridges. P. L. BROCKWAY. Pub. Works, 55: 239–41, 1924. Discusses designs for carrying pipe lines on bridge.—*Langdon Pearse.*

Metropolitan District Plans in Maryland. ABEL WOLMAN. Pub. Works, 55: 242–5, 1924. Discusses districts formed, financing, and results.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Some Things to Know About a Sprinkler System. Proper Installation of Sprinkler Systems. CLAUDE C. BROWN. Fire & Water Eng., 75: 113, January 16; 209, January 30, 1924. Two practical articles by the mechanical and electrical engineer of California State Railroad Commission.—*Geo. C. Bunker.*

The Water Works Man's Responsibility. J. Z. MARTIN. Fire & Water Eng., 75: 203, January 30, 1924. General discussion before Texas Short Water Works School.—*Geo. C. Bunker.*

Cutting Pumping Costs With Oil Engine Driven Generator. ARTHUR L. GREENE. Fire & Water Eng., 75: 207, January 30, 1924. Water supply for Gloucester, N. J., from six driven wells. Iron removed by aëration, sedimentation, and filtration through six rapid sand filters, each with capacity of ½ m.g.d. It was decided to rebuild old pumping plant to cut down excessive cost of pumping and repairs, and to reduce number of pumpings from 3 to 2. Diesel engine driven generators furnish motive power. Water is lifted from wells to aërator by motor driven centrifugal pumps which operate at 1150 r.p.m. against total head of 58½ feet with ordinary suction draft varying from 24 to 26 feet. Pumping under this unusually high suction lift is made possible through removal of air and maintenance of constant vacuum by use of Rotex vacuum pumps, one of which is in constant operation. The maximum suction lift was decided upon in order to obtain maximum yield from wells. Three high service centrifugal pumps of same capacities operate at 1750 r.p.m. against a total head of 145 feet. Pumps are so inter-connected that various combinations of capacities may be made, from 1 to 4.5 m.g.d., while discharge pressure may also be varied as desired; operated in tandem or in series. Latter desirable when necessary to increase discharge pressure for fire. Three phase, 60 cycle, 220 volt operating current is supplied by two generator sets, Diesel oil engine direct connected to generators. One unit in constant operation without stop for perlod of 6 to 8 weeks. Two men employed during each shift. Operating at ¾ normal capacity, cost of water per 1000 gallons, pumped twice and filtered, is 2.72 cents, which includes operating expenses, interest and depreciation.—*Geo. C. Bunker.*

When You Think of Fire, You Think of Water. A. A. SPRAGUE. Fire & Water Eng., 75: 253, February 6, 1924. In 1923, National Board of Fire Underwriters surveyed water system of Chicago; reported consumption was excessive, and that pressure in some important sections was too low for adequate fire engine supply. These conditions exist now. Daily waste equals two-thirds supply of New York, whose population two and one-half times greater; also larger than total pumpage of Detroit, Cleveland, and Buffalo, with combined population of two and one-half millions. If present waste continues unchecked, it is estimated that in next 20 years, additional sewerage construction alone will cost $24,000,000, while in sewage works operation and pumpage, further $24,000,000 will be lost. Assuming 3,600,000 population for Chicago by 1930, daily water consumption under present wasteful methods will be 1,354,000,000 gallons, calling for additional 800,000,000 gallons daily capacity in cribs, tunnels, pumping stations, and feeder mains. If system meterized properly, and waste cut down, practically all of this work could be postponed for more than 15 years, and in the next 25 years, not less than $285,000,000 would be saved to city. Address before the City Club. Cf. this JOURNAL, 10: 1135, 11: 492.—*Geo. C. Bunker.*

Reducing Water Waste by House-to-House Inspection. EDWARD NUEBLING. Fire & Water Eng., 75: 257, February 6, 303, February 13, 1924. N. Y. City has about 10,000,000 water fixtures in homes of domestic consumers who are substantially all supplied on frontage rate basis. Under

these conditions, aggregate leakage from fixtures will amount to 20 per cent of total supply, if unchecked for several years. Only means at disposal for checking waste in unmetered premises has been house-to-house inspection. Improvement gained is only temporary and inspection must be repeated at intervals to maintain reduction in consumption initially effected. Continuous inspection over prolonged periods has not been undertaken. As temporary expedient, it has proven of great value during periods of actual or threatened shortage. Methods of conducting the work are described and results given, of studies made as to amount and nature of fixture leakage and attainable reduction in consumption. Inspectors work in squads of about 12 men; each squad being under trained supervisor. About 1 clerk is required to every 5 inspectors. Organization is under immediate direction of chief inspector of the borough bureau of water register. Printed forms of pocket size for recording the data are described. Nearly all fixture leakage found due to worn faucets, toilet, and other outflow valves. Life of valve, i.e., time that will elapse before leakage takes place, depends upon amount of usage. Valves used only occasionally, say once or twice a year, may last indefinitely. Kitchen faucets and toilet valves in daily use will permit leakage in from 2 to 3 years. By measuring such leaks as could be caught with cup and estimating others, average leakage in typical districts in boroughs of Manhattan, The Bronx, and Brooklyn was found some 20 years ago to vary from 170 g.p.d. in better class residential districts to 450 g.p.d. in tenement and mfg. districts. No recent gaugings of individual leaks have been made. Average for all classes, determined from measured consumption before and after inspections during recent years and from total number of leaky fixtures found, is between 350 and 400 g.p.d. If no inspections were made for several years, and no other means of control employed, the aggregate of fixture leakage would equal 153 m.g.d., or 21 per cent, of present supply of 735 m.g.d. An average of about 3 per cent of all fixtures examined are found to be leaking. Remaining 97 per cent are in various stages of wear. New leaks may therefore begin to develop immediately and in about 2 years time about 3 per cent of fixtures in use will again be leaking. Thereafter, leakage will remain fairly constant, development of new leaks being offset by voluntary suppression of other leaks. Most economical size of force is one that would cover the city once in 2 years. At present wages; $1560 per annum for inspectors, $1700 for supervising inspectors and $1560 for clerks; after allowing for supplies and overhead, cost per million gallons saved would be $6. To cover city once a month, cost would be $53, 1440 inspectors being required. Universal metering would neither stop all waste from leaky fixtures nor those uses considered improper and illicit under frontage rate basis. Metering would probably have same effect as continuous house-to-house inspection, repeating itself every 6 months; in other words, a permanent saving equal to about 18 per cent of supply. Cf. this JOURNAL, 11: 324.—*Geo C. Bunker.*

A Comparison of American and British Water Works Methods. GEORGE MITCHELL. Fire & Water Eng., 75: 300, February 13, 1924. Discussion of Rainfall and Stream Gauging; Sources of Water Supply; Impounded Reser-

voirs; Reservoir Dams; River Supplies; Purification Works; Mechanical Filters; Slow Sand Filtration; Aqueducts; Pumping Machinery; Service Reservoirs; Distribution; General.—*Geo. C. Bunker.*

Data on Which Design of a Purification Plant Should Be Based. C. ARTHUR BROWN. Fire & Water Eng., 75: 349, February 20, 1924. Discussion of 21 points, concerning which author, in working out designs for purification plants, has found it helpful to obtain data and prepare graphs. Paper read before Texas Short Water Works School.—*Geo. C. Bunker.*

What a Leakage Survey Did For One City. WILLIAM A. NIAL. Fire & Water Eng., 75: 352, February 20, 1924. Direct results of Pitometer water waste survey in Troy, N. Y.: 5 m.g.d. of underground leakage stopped; one leak from a 2-inch lead service was wasting 850,000 g.p.d. and had washed out a hole under trolley tracks 15 by 12 by 9 feet deep, water finding its way into sewer; household waste of 8.375 m.g.d. from 3,729 leaking fixtures and commercial use of 1.45 m.g.d. were proved. Re-inspection reports show very small percentage of repair orders have been obeyed. Per capita consumption of Troy is 300 g.p.d., whereas 100 g.p.d. is considered as ample. Filtration system for present supply, would, if waste were eliminated, be sufficient for at least thrice the present population. Other advantages of reduction in consumption are pointed out. Illus.—*Geo. C. Bunker.*

A Municipal Water Works Advertises to Sell More Water. BEEKMAN C. LITTLE. Fire & Water Eng., 75: 395, February 27, 1924. Describes illustrated folder distributed to each house with water bills.—*Geo. C. Bunker.*

Regulations Covering Oil Burner Installations. Fire & Water Eng., 75: 397, February 27, 1924. Amendments to Fuel Oil Rules. Construction and Installation of Oil Burning Equipment and Storage and Use of Oil in Connection Therewith. Adopted by the N. Y. Board of Standards and Appeals on January 18, 1924.—*Geo. C. Bunker.*

Modernizing Electrical Equipment in Water Plants. F. C. BOLTON. Fire & Water Eng., 75: 399, February 27, 1924. Instructive discussion of characteristics of squirrel cage and wound rotor induction motors, brush shifting motors, synchronous and supersynchronous motors, and of their use with reciprocating, rotary, and centrifugal pumps. Perhaps the two most notable advances in electrical equipment for water works use in water plants have been (*a*) development of the brush shifting motor for variable speed and (*b*) the supersynchronous motor, providing high starting torque with high power factor. Paper read before Sixth Short Course for Water Works and Filter Plant Operators at Waco, Texas.—*Geo. C. Bunker.*

Report of the Commissioners of Water Works in the City of Erie, Pa., for the Year Ending December 31, 1923. 1924: 67. The 57th annual report, largely financial, is presented. Cost of water sold was $22.182 per million gallons, included in which is $0.367 for alum, 0.143 for bleach, and 0.052 for

laboratory supplies and expense. Purification system expenses were $6.615 and operation of pumps $14.962 per million gallons. Number of gallons pumped per pound of coal was 252.3. Alum applied averaged 0.142 g.p.g. and bleach 3.7 pounds per million gallons. Daily per capita consumption was 204.68 gallons total and 118.06 after deducting water delivered through metered services which constitute 2.81 per cent of total. Table included showing monthly average analyses (bacteriological and chemical) of raw and filtered water.—*R. E. Thompson.*

How to Interpret a Water Examination Report. Weekly Bulletin, Cal. St. Bd. of Health, 3: 20, 77, June 28, 1924. Popular explanation of significance of analytical results, with brief outline of sources of pollution.—*E. S. Chase.*

Faulty Sewers Near Water Works Prohibited. Weekly Bulletin, Cal. St. Bd. of Health, 3: 21, 82, July 5, 1924. As result of two outbreaks of typhoid, due to proximity of faulty sewers to water works, Cal. St. Bd. of Health established regulations for protection of water works and water supplies from the like. In effect, cast iron sewers with lead joints are required wherever leakage would result in pollution of underground water sources; and similar pipes, where low pressure water lines pass through areas subject to pollution; and all water supplies whose surroundings are open to suspicion must be disinfected.—*E. S. Chase.*

Regulations for the Sanitation of Watersheds, the Water From Which is used as a Public Water Supply Unfiltered. State of Conn. Health Bull., 38: 7, 167, July, 1924. Regulations prohibit cesspools, privies, etc. within 50 feet of high water mark of reservoirs or water courses. No cesspool, privy, etc. shall be located within 250 feet of high water mark unless so constructed that no portion of contents can reach stream or reservoir. No polluted water shall be discharged into ground within 50 feet of high water mark and none shall be discharged upon ground within 250 feet thereof. No animal enclosure shall be located within 50 feet of high water mark, nor within 250 feet, unless provision made to prevent polluted water flowing or washing into streams, etc.—*E. S. Chase.*

How the Laboratory Tests Water. State of Conn. Health Bull., 38: 168, July, 1924. Popular article describing methods and interpretation of water analyses.—*E. S. Chase.*

Surface Drainage into Well Supplies. L. A. Geupel. Monthly Bull. Indiana St. Bd. of Health, 27: 6, 85, July, 1924. Points out danger of contamination of poorly protected wells. In 1922 and 1923, laboratory tests showed 75 per cent of dug wells and 30 to 40 per cent of deep wells unsatisfactory for drinking purposes.—*E. S. Chase.*

Abstract of Address by Dr. William F. King. Monthly Bull. Indiana St. Bd. of Health, 27: 8, 113, August, 1924. There are approximately 214 public water supplies in Indiana, of which 174 are ground water and 40 surface

supplies. Of water consumption, 62 m.g.d. is from ground water and 100 m.g.d. from surface sources. Due to typhoid outbreak in October, 1923 in one of larger cities of Indiana, involving 157 cases and 23 deaths, due to cross connection between city main and polluted industrial supply, State Board of Health has ordered elimination of all cross connections where fire supplies are from surface sources. Board has also ordered that on and after June 1, 1926, no raw or insufficiently purified sewage shall be discharged into any of lakes of Indiana.—*E. S. Chase.*

The Relation Between Iodin in Food and Drink and Goiter. Quart. Bull. Louisiana St. Bd. of Health, **15**: 3, 126, September, 1924. Many samples of water over the United States have been analyzed for iodin with results ranging from 1 part to 18,470 parts in 100,000,000,000. New Orleans water supply from Mississippi contains 770 parts per 100,000,000,000.—*E. S. Chase.*

New Jersey Water Supplies. New Jersey Public Health News, **9**: 10, 292, September, 1924. All but 5 of New Jersey public water supplies which are derived from surface sources are subject to some form of purification. There are in state some 75 water purification plants.—*E. S. Chase.*

A Common Incident and Some Common Sense. H. E. Miller. Health Bull. N. C. St. Bd. of Health, **34**: 8, 16, August, 1924. Popular article regarding protection of springs and wells from pollution.—*E. S. Chase.*

The Sanitary Water Board. W. L. Stevenson. The Listening Post, Pa. Dept of Health, **2**: 15, 7, June, 1924. Outline description of powers and duties of Sanitary Water Board of Pa., with resolution of Board regarding classification of streams.—*E. S. Chase.*

Typhoid Fever in Spring Township, Center County. Dr. E. S. Everhart and L. D. Matter. The Listening Post, Pa. Dept. of Health, **2**: 16, & 17, 38, July and August, 1924. Account of outbreak of typhoid in small industrial settlement, due apparently to infected water supply. In 8 double houses constituting settlement, there were 14 cases.—*E. E. Chase.*

Examination of Semi-Public Water Supply along State Highways. Anon. The Listening Post, Pa. Dept. of Health, **2**: 18, 21, September, 1924. On July 1, 1924 Engineering Division of Pa. Dept. of Health began examination of semi-public water supplies along public highways. Primary object was to provide travelling public with safe water supplies. In case of satisfactory supplies, Dept. posted "safe water" placard.—*E. S. Chase.*

Burning Boiler Oil in Diesel Engines. C. L. Ruegg. Power, **60**: 13, 488, September 23, 1924. As demand for light fuel has exceeded production, marked increase in price of these oils, in comparison with that of heavier grades, has resulted. Consequently some Diesel Engines are now operated with cheap heavy oils. Engine builders have developed fuel pump and heating system designed to successfully handle fuels at comparatively low tem-

peratures. At Nacozari, Mexico, 9400 h.p. Diesels are operating at 3500 feet above sea level, using, with entire success 14-degree oil containing 4.5 per cent sulphur.—*Aug. G. Nolte.*

Starting and Stopping Steam Turbines. C. C. BROWN. Power, 60: 13, 489, September 23, 1924. Standard procedure for starting up and shutting down some three-stage, 3600 r.p.m., 140 to 160 pound throttle pressure, 10 to 15 pound exhaust, rigid type frame, 1875-kva. turbine units is given.—*Aug G. Nolte.*

Proportioning Water-Works Surface Condensers. W. R. FREEMAN. Power 60: 14,529, September 30, 1924. Various formulas and curves which may be used to advantage in proportioning of water-works condensers. Typical example to illustrate their application is worked out.—*Aug. G. Nolte.*

New Byllesby Plant Near Muskogee. Power, 60: 15,562, October 7, 1924. Two new turbine stations supply extensive system throughout Oklahoma. Layout and general design of Muskogee Plant is described. It is equipped to burn coal or oil and has complete water softening and clarifying system. —*Aug. G. Nolte.*

Buying Second-Hand Machinery. JOHN CASSIDAY. Power, 60: 15,571, October 7, 1924. Some valuable pointers to enable prospective purchaser to discover defects likely to be found in second-hand machinery.—*Aug. G. Nolte.*

Tests for Determining Type of Direct-Current Machines. B. A. BRIGGS. Power, 60: 15,573, October 6, 1924. The author shows how to distinguish between different types of direct-current motors; also between direct-current machines and alternating-current commutation-type motors.—*Aug. G. Nolte.*

Handling Oil-Fired Boilers. A. SMITH. Power, 60: 15,577, Ocrober 7, 1924. Pumping of oil, its temperature, and method of firing are discussed. —*Aug. G. Nolte.*

Removal of Scale with Carbon Dioxide. C. L. JONES. Power, 60: 15,578, October 7, 1924. This method finds application mostly to special problems because only certain types of scale amendable to treatment. Applicability of procedure may be tested in advance by subjecting small sample of scale to action of carbonated water in pressure bottle. It appears that procedure works best in practice on scales high in silicates and low in carbonates. Limited solubility of calcium bicarbonate in water has, in at least two recent instances, been evident cause of failure to remove scale with CO_2. Pipe lines and pumps at large Pittsburgh steel works have been cleaned with liquid CO_2. As result of experience, author suggests number of points for consideration of engineers who have problems in removal of deposit from pipe lines, etc.—*Aug. G. Nolte.*

Pulverized-Coal Boiler Performance, Brunot Island Power Station. L. W. HELLER. Power, 60: 16,600, October 14, 1924. Desirable characteristics of this installation, which will be dominating factors in selection of furnace equipment in the future, and factors of extreme importance in operation and design of boiler plants are: (1) comparatively high efficiency can be attained without employment of highly skilled operators; (2) system lends itself to automatic regulation; (3) absence of mechanical parts in hot zone of furnace permits unit to be operated for long periods without outage for repairs; (4) boiler tubes are not subjected to appreciable accumulation of slag or ash; (5) high evaporative capacities can be secured with low draft loss through boiler, because of low gas volume per unit of fuel.—*Aug. G. Nolte.*

Temperatures in Water Tube Boilers. Power, 60: 16,603, October 14, 1924. Investigations at Rensselaer show that variation in temperature in boiler at any given time is practically nil; maximum variation which occurred during one of three tests was 7 degrees.—*Aug. G. Nolte.*

Loading the Boilers to Obtain Maximum Efficiency. C. E. COLBURN. Power, 60: 17,642, October 21, 1924. Essential for high efficiency in boiler room is comparatively low boiler rating. Only under such conditions can stokers be controlled to maintain even fire, with good ash conditions, and fair percentage of CO_2. In forcing boiler, fire may be controlled for a time, but CO_2 goes up eventually and with it furnace temperature and then trouble begins. It is wise to divide load among operating boilers so that each is at its best point. Strict attention should be paid to keeping controllable losses at their lowest.—*Aug. G. Nolte.*

Locating Faults in Synchronous Motors. B. A. BRIGGS. Power, 60: 17, 644, October 21, 1924. Troubles liable to develop when starting synchronous motors are enumerated and discussed. Methods to locate faults are suggested.—*Aug. G. Nolte.*

Installing an 1875—kva. Impulse Steam Turbine. C. C. BROWN. Power, 60: 17,648, October 21, 1924. Short résume of number of carefully worked out details in installation of each of four steam turbo-generators at plant of one of large western sugar refineries.—*Aug. G. Nolte.*

Systematic Control of Boiler Water Concentration. C. M. WARE. Power, 60: 17,650, October 21, 1924. Systematic manner of maintaining highest, safest, and most economical concentration is recommended. Object may be accomplished by determining total solid content. Sample collected must be representative. One of three following methods of analysis may be applied. (1) Concentration-meter, electrical device consisting of low voltage meter, which indicates concentration directly; (2) weight of residue on evaporation in platinum dish; and (3) chloride content determination. There is usually fairly definite ratio of chloride to total solid content, which may be determined by partial analysis. Chart for determining blow-down frequency to maintain desired concentration is presented.—*Aug. G. Nolte.*

Handling Twelve Boilers with One Orsat. Power, **60**: 17,657, October 21, 1924. Arrangement whereby twelve large boilers are effectively served by single Orsat is illustrated and described.—*Aug. G. Nolte.*

Diesel Engines Eliminate Losses in Carthage Light Plant. Power, **60**: 18, 684, October 28, 1924. 750-h.p. two-stroke-cycle Diesel, direct connected to 500-kw. generator, was placed in service in 1921. After short period of training and instruction, men who had operated steam engines mastered operation of Diesel. For 30 months, Diesel was kept in almost continuous service. Then another unit of 1250 h.p. direct-connected to 1050-kva. generator was placed in service for handling heavy load period. By installation of Diesel Engines, production costs were reduced to below one cent per kilowatt-hour.—*Aug. G. Nolte.*

Current Court Decisions Pertaining to Public Health. Public Health Reports, **39**: 42, 2634, October 17, 1924. (1) Use as cemetery of land near water supply restrained; (2) City liable for sewage pollution of stream.—*Aug. G. Nolte.*

Questions and Answers. FRANKLIN VAN WINKLE. Power, Questions are asked and answers given on following subjects: **60**: 13, 508, September 23, 1924. Loss Due to Cooling Internal-Combustion Engine; Use of Copper for Steam Piping; Advantages of Suspended Boiler Setting; Babbitting Boxes of Small Engine; Action of Holding Coil on Starting; Submergence for Air Pipe; Shortest Cutoff for Throttle-Governed Slide-Valve Engine; Direction of Running Motor-Driven Compressors. **60**: 14, 548, September 30, 1924. Advantage of Swing Check Valves; Additional Steam Required by Increase of Back Pressure; Bulge in Ligaments of Tube Sheet; Advantages of Radiators over Long Wall Coils; Allowable Pressure for Outside Sheet of Stayed Water Leg; Removal of Water from Ammonia Refrigerating System; Hard and Soft Boiler Patches; Loss from Use of Vented Receiver; Correction of Bourdon Pressure Gage; location of Fusible Plug in Return Tubular Boiler; Advantages of Double Eccentric Corliss Valve Gear. **60**: 15, 588, October 7, 1924. Burning of Clean Heating Surface; Extension of Boiler-Heating Surface into Uptake; Rating at which Specific Speed of Hydraulic Turbine is Based; Resetting Slipped Eccentric; Suction and Discharge Pipe Sizes; Repairing Crack around Upper Part of Chimney; Determining Percentage of Moisture in Coal; Lengthening Arms of Pendulum Governor Reduces Engine Speed. **60**: 16, 624, October 14, 1924. Standing of Governor After Increasing Compression; Use of Blowoff; Injection Water for Vacuum Heating; Computing Pump Capacity; Cutting of Valves and Seats; Cooling Effect of Fresh Coal; Equalizing Cutoffs of Corliss Engine; Back Pressure in Compound Engine. **60**: 17, 662, October 21, 1924. Higher Thermal Efficiency from Lean Mixture; Settling of Front Ends of H. R. T. Boilers; Selection of Indicator Springs; Lost Motion of Steam Valves of Duplex Pump; Cost of Elbows in Exhaust Pipe. **60**: 18, 703, October 28, 1924. Action of Unbalanced Pressure of Atmosphere in Operation of Suction Lift; High Ammonia Suction Temperature; Capacity of Power Line; Changes in System Frequency;

Obtaining Volt-Amperes in Three-Phase System; Pumpage Limited by Head Pressure.—*Aug. G. Nolte.*

The Corrosion of Iron. N. A. Bouchkoff. L'Oural No. 1922, 3–10; Rev. metal., **20** (Extraits): 425–6, 1923. From Chem. Abst., **18**: 216, January 20, 1924. Investigation of optimum conditions for formation of rust. Preliminary tests showed 0.2 per cent acetic acid to be one of the best corroding agents and optimum time of action to be about 15 min. Conclusions are: (1) corrosion is due to internal thermoelectric couple formed in metals having liquation zone; (2) the metal is not homogeneous and portion containing pure iron is most rapidly corroded; (3) manganese sulphide and its alloys are more resistant than pure iron; (4) purer the metal the more uniform the layer of rust; (5) sudden variations in temperature contribute to corrosion; (6) greater the difference in temperature in a piece of iron the greater the tendency to corrode.—*R. E. Thompson.*

The Distribution and Therapeutics of Iodine. A. J. Quimby. Am. Med., **18**: 223–7, 1923; Pub. Health Eng. Abst., August 25, 1923. From Chem. Abst., **18**: 141, January 10, 1924. Use of drinking water freed from proper mineral salts (snow or distilled water) should be discouraged. In selecting municipal supply, attention should be paid to iodine content. Possibility of supplementing existing supplies with iodine-bearing waters suggested. Theories concerning physiological action of iodine reviewed.—*R. E. Thompson.*

The Sorption Capacity of Aluminium Hydroxide. H. v. Euler and Elsa Erikson. Z. physiol. Chem., **128**: 1–8, 9–13, 1923. From Chem. Abst., **18**: 187, January 20, 1924. Nucleic acid is sorbed over pH range of 3–7. Rate of sorption of phosphoric acid depends on pH of solution. Term "sorption" implies nothing concerning mechanism of process, although chemical forces are no doubt considerably concerned.—*R. E. Thompson.*

A Rapid Gasometric Method of Estimating Dissolved Oxygen and Nitrogen in Water. H. G. Becker and W. E. Abbott. Sci. Proc. Roy. Dublin Soc., **17**: 249–53, 1923. From Chem. Abst., **18**: 139, January 10, 1924. Method, requiring only 20 to 30 cc. of water, described, in which air is expelled by contact with solid potassium hydroxide and measured before and after absorption in alkaline pyrogallol. Other salts were tried in order to reduce cost. Sodium hydroxide was as effective but tended to crystallize and block capillaries. Magnesium chloride and calcium nitrate expelled most of the air but the rate was slow. Fused potassium chloride required 20 to 30 minutes to expel 95 per cent, compared with 1 to 2 minutes with potassium hydroxide. Sodium sulphate, citric acid, calcium chloride, sodium carbonate, sodium thiosulphate, zinc chloride and alum were unsatisfactory. Glycerol and sulphuric acid gave rapid and nearly complete expulsion. Normal ammonium chloride contains only 0.07 cc. of oxygen per liter; but, whereas with potassium hydroxide the heat evolved accelerates expulsion, absorption of heat by ammonium chloride militates against expulsion. Total air by new method

was consistently greater, and oxygen, less, than standard values, the latter probably due to imperfect absorption.—*R. E. Thompson.*

The Mineral Water of Challes-les-Eaux (Savoie). D'ARSONVAL, F. BORDAS AND F. TOUPLAIN. Ann. fals., **16**: 402–10, 1923. From Chem. Abst., **18**: 140, January 10, 1924. Combined carbon dioxide was determined by oxidizing sulphur compounds with lead peroxide and hydrogen peroxide, filtering, evaporating, liberating carbon dioxide with sulphuric-chromate mixture, absorbing in sodium hydroxide-calcium hydroxide, and weighing.—*R. E. Thompson.*

The "Positive" Flue Gas Analyzer. ANON. Technique moderne, **15**: 709, 1923. From Chem. Abst., **18**: 183, January 20, 1924. Description of a small compact, and sturdy apparatus for determination of carbon dioxide in flue gas, based on same principle as the Orsat, but simpler and easier to manipulate.—*R. E. Thompson.*

The Most Recent Progress in the Technic of High-Pressure Steam of Sixty Atmospheres or over, Based on the Experiments of Wilhelm Schmidt and the Schmidt Steam-Heating Co., Ltd., Kassel-Wilhelmshöhe. O. H. HARTMANN. Chem. App., **10**: 101–3, 111–2, 118–9, 128–30, 156–7, 1923; 17 cuts. From Chem. Abst., **18**: 183, January 20, 1924. Generation and use of high-pressure steam have been practically demonstrated: boilers and engines of greatest power and safety in operation can be constructed. Boiler is described which has been operated 16,000 hrs. and will deliver about 1340 kgm. steam per hour at 480° with grate surface of 1.44 square meters and total heating surface of 72 square meters. Steam at 30 atmospheres or over, working through engines at over 10 atmospheres back-pressure, with utilization of exhaust for heating, is more economical than condensing system. Steam consumption per h.p.-hour., with condenser, is about 2.5 kgm., against 4 kgm. with steam at 15–20 atmospheres; heat consumption is about 2000 kgm.-cal. against 2800–3000 kg.-cal.; and coal consumption about 0.36 kgm. against 0.5–0.6 kgm. at usual pressures.—*R. E. Thompson.*

Chlorine. J. W. VAN METER. Brit. 199,052, December 12, 1921. From Chem. Abst., **18**: 184, January 20, 1924. Apparatus for application of chlorine in water purification, etc., consists of an upper chamber adapted to receive a continuous supply of liquid, which is then fed to a lower transparent vessel in which is disposed a second transparent vessel, open at bottom, graduated, and having a bleeder port for passage of chlorine to outer vessel. —*R. E. Thompson.*

Water Supply and Purification of Waste Water. ANON. Hanomag-Nachrichten, January, 1923; Dinglers polytech. J., **338**: 73, 1923. From Chem. Abst., **18**: 139, January 10, 1924. Illustrated description of equipment and processes for water supply and purification employed at Hannover, Oldenburg, Lehe, Cleve, Schwerin, Bochum, Geestemunde, Erfurt, Barmen, etc.

The "Ter Meer" centrifugal process has attained great success in Frankfurt, Hannover, Harburg, Bielefeld, etc.—*R. E. Thompson.*

Permutite Process of Water Softening. G. H. Rome. Am. Dyestuff Rep., **12**: 613–4, 1923. From Chem. Abst., **18**: 139, January 10, 1924. It is advantageous to use softened water in textile industry. Zeolites recommended.—*R. E. Thompson.*

Special Applications of Chemical Data to Water-Supply Investigations. W. M. Cobleigh. Abstracts Bact., **5**: 26, 1921. From Chem. Abst., **18**: 140, January 10, 1924. Introduction of 100 pounds sodium chloride into cesspool caused chlorine content of deep drilled well 200 feet distant to increase from 2.8 to 23 p.p.m. in 24 hours.—*R. E. Thompson.*

Micro-Sampling for the Determination of Dissolved Oxygen. R. V. Allison and J. W. Shive. Soil Science, **15**: 489–91, 1923. From Chem. Abst., **18**: 142, January 10, 1924. Method of sampling for determination of dissolved oxygen by micro-Winkler method described.—*R. E. Thompson.*

The Effect of Magnesium Chloride of Mineral Waters on the Secretion of Glands Emptying into the Intestine. P. Carnot and H. Gaehlinger. Compt. rend. soc. biol., **88**: 1129–31, 1923. From Chem. Abst., **18**: 123, January 10, 1924. Experimental evidence given of effects of magnesium chloride and sulphate, of sodium sulphate, and of Chatelguyon mineral waters.—*R. E. Thompson.*

Method of Detecting and Preventing Lead Poisoning. J. Schoenfeld. Farbe u. Lack, 1922, 370 (Nov. 23); Chimie et industrie, **10**: 493, 1923. From Chem. Abst., **18**: 124, January 10, 1924. Lead absorbed through mouth is transformed in stomach to lead chloride and passes into blood, causing granulation of red corpuscles (about 30–15,000 per million). Blood analysis surely detects intoxication, and progress of recovery can also be followed by this means. Best treatment is fresh air cure, ranging from several weeks to months.—*R. E. Thompson.*

The Thyroid and Iodine, in Relation to the Prophylaxy of Goiter. F. de Quervain. Schweiz. med. Wochschr., 1922, 857: Schweiz. Apoth. Ztg., **61**: 365–6, 1923. From Chem. Abst., **18**: 126, January 10, 1923. Use of iodine in treating existing goiter in adults dangerous; but preventive measure among young might consist of systematic (optional) use, under constant medical supervision, of sodium chloride containing smallest effective dose. Sale of iodine products for use in goiter should be regulated, and scientific study of prophylaxy continued.—*R. E. Thompson.*

Corrosion by Acid Water. D. H. Jackson. Power, **58**: 217, 1923. From Chem. Abst., **18**: 45, January 10, 1924. Water may contain sufficient acid to be injurious to boilers and yet not give an acid reaction with methyl orange. Use of either potentiometric or colorimetric method for determin-

ing H-ion concentration is advised. Corrosiveness of distilled water from condensate returns, when it contains dissolved oxygen, is pointed out.—*R. E. Thompson.*

The State of Methyl Orange and Methyl Red in the Change-Point Interval. A. THIEL AND A. DASSLER. Ber., **56B**: 1667–71, 1923. cf. Bjerrum, C. A., **17**: 2379. From Chem. Abst., **18**: 56, January 10, 1924. A study of helianthin (acid of methyl orange) and methyl red along same lines as Bjerrum's investigations.—*R. E. Thompson.*

Rapidity of the Reaction Change in Stream Waters. MARCEL DUVAL AND P. DUMARAUD. Compt. rend. soc. biol., **89**: 398–400, 1923. From Chem. Abst., **18**: 90, January 10, 1924. The pH of the water changes from 7.1 to approximately 8, as it runs from source to end of course. Agitation is believed to be principal cause of this change. Plants bear a considerable share in in process of alkalinization, probably independent of presence of chlorophyll. —*R. E. Thompson.*

The Shotter Electrolytic Flow Meter. G. F. SHOTTER. Electrician, **89**: 209–11, 1922. From Chem. Abst., **16**: 3593–4, November 10, 1922. Apparatus designed to measure depth of liquid, adaptable to measuring height or flow over weirs, described, action of which is dependent on electrical conductivity of liquid. Indicating and recording points may be situated some distance from measuring point.—*R. E. Thompson.*

The Determination of Sulphuric Acid as Barium Sulphate in the Presence of Aluminum. L. MOSER AND P. KOHN. Z. anorg. allgem. Chem., **122**: 299–310. 1922. From Chem. Abst., **16**: 3601, November 10, 1922. Aluminum, like ferric iron, interferes with determination of sulphate as barium sulphate, but error is not as great as with latter and tends to reach maximum as aluminum content increases. Probable cause of error is formation of solid solution of aluminum sulphate in the barium sulphate, resulting in loss of SO_3 on ignition, loss being greater than weight of aluminum in precipitate. Error is not more than 0.15 per cent if for each gram of barium sulphate the volume of the solution is made up to 275 cc., 20 cc. normal hydrochloric acid added and precipitant added slowly at boiling temperature. Filtration can be carried out without much delay if filter pulp is added.—*R. E. Thompson.*

Corrosion of Iron and Steel. Influence of Molecular Concentrations on Immersion-Test Investigation. D. M. STRICKLAND. Chem. Met. Eng., **26**: 1165–9, 1922. From Chem. Abst., **16**: 3625, November 10, 1922. Initial rate of corrosion most important, since solution rates change as equilibrium approaches. Spent solutions, although often harmless, sometimes accelerate corrosion. Logical method for comparative tests consists of short tests in circulating pure chemicals.—*R. E. Thompson.*

The Capacity of City Water Works. GIESSLER. Zentr. Bauverwaltg., **39**: 413–4, 1919. Wasser u. Abwasser, **15**: 306, 1921. From Chem. Abst.,

16: 3721, November 10, 1922. Assumed daily consumption of 60 liters per capita was found ample in design of Pasewalk waterworks. Census of 22 cities between 8,000 and 52,000 population indicated that average consumption was lower than this.—*R. E. Thompson.*

A Source of Contamination of Cistern Water. LEONARD GREENBURG. U. S. Public Health Reports, 37: 1825–9, 1922. From Chem. Abst., 16: 3722, November 10, 1922. Cistern water was contaminated by lead from flashing on roof of buildings. Use of lead in roof construction discouraged. Cf. this JOURNAL 9: 5, 837.—*R. E. Thompson.*

The Abnormal Temperature of Iron-Containing Springs. C. MEZGER. Städtische Tiefbau, 11: 51: Wasser u. Abwasser, 15: 253, 1920. From Chem. Abst., 16: 3722, November 10, 1922. Abnormally high temperature of three iron-bearing springs possibly due to exothermic oxidation of iron compounds. —*R. E. Thompson.*

Action of Ground Water on Concrete Sewer Pipe. C. A. NEWHALL. Contract Record, 36: 287–8, 1922; Public Health Engineering Absts., September 16, 1922. From Chem. Abst., 16: 3722, November 10, 1922. Limitations of concrete given. Cement sewer pipes and drain tile are not capable of resisting corrosive action of carbon dioxide in ground water.—*R. E. Thompson.*

Goiter in Würtemberg. BETZELZER. Med. Korresp. Bl. f. Wurtt., 92: 39–47, Zentralbl. f. d. ges. hyg., March 10, 1923, p. 272; Bull. men. office internat. d'hyg. publique, 16: 366, 1924. Goiter is frequent. Advises weekly dose of 0.01 to 0.03 gr. I for children.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

New Contribution to the Study of Endemic Goiter. GIACOMO PIGHINI. Il Policlinico, (sez. practica) 31: 452, 1924; Bull. mens. office internat. d'hyg. publique, 16: 632, 1924.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Extension of Endemic Goiter in Switzerland According to the Most Recent Results of Medical Inspection of Recruits. C. STINER. Schweiz. med. wochenschrift, April 24, 1924; p. 391; Bull. mens. office internat. d'hyg. publique, 16: 921, 1924. Young men from goiter region may be 50 per cent affected, proportion may reach 80 per cent in some cantons. Largest number rejected is from 20 to 30 per cent. Apparently goiter is on increase. S. thinks type of food a cause, and that shortage of vitamines may be partially responsible.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Report of the Dutch Commission for the Experimental and Statistical Study of Causes and Prophylaxis of goiter at Utrecht. Utrecht, 1924. Reproduced in Tijdschrift voor Geneeskunde, May 17, 1924, p. 2274; Bull mens. office internat. d'hyg. publique, 16: 923, (1924). Commission was instituted in 1918. Experimental studies on rats and statistical studies on school children are reported.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

An Epidemic of Typhoid Fever and its Economic Consequences. KATHE AND SCHAEDE. Centralblatt f. Bakt., 90: 129, 1923: Bull. mens. office internat. d'hyg. publique, 16: 477, April, 1924. In July, 1921, in contiguous communities of Dittersbach and Oberwaldenberg, began an epidemic that in 5 months produced 639 cases. Fatality was 9.7 per cent. Surface water contaminated by known case penetrated collecting gallery. Contact cases were 214; those obviously water borne, 425. Hospital system was very effective in reducing fatality, but was very expensive, necessitating special tax. —*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Peculiar Properties of Water in the Light of its Molecular Structure. F. O. ANDEREGG. Proc. Indiana Acad. Science, 39: 93–101, 1924.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Sanitation of Watering Places for Animals. Revue de Zootechnie, April, 1923; L'Eau, 16: 44, 1923. Aqueous cachexia among sheep is communicated to cattle by pond water, or by parasites on aqueous vegetation. Glanders is also transmitted by water, also tuberculosis and foot and mouth disease. Water should be pure and constantly renewed. Chemical methods of purification of pond water are given.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Artesian Wells of Northern Africa. ANON. L'Eau, 17: 66, 1924. Government agencies are putting down wells to revivify oases and to furnish water to soldiers. Depths are 50 to 190 meters. Algerian wells have yielded well, but those in Morocco have been too salty or have not flowed.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Subterranean Waters of the Cambrai Region. M. L. DOLLÉ. L'Eau, 17: 61–66, 1924. Geological water supply paper.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Hard Water and Water Softening. E. F. BADGER. Public Health (Michigan), 12: 113–117, 1924. General paper with cost data.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Artesian Basins of Australia. ED. IMBEAUX. L'Eau, 16: 98, 1923. —*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Instruments, Theories, and Field of Exploration of Water Diviners. L. DESCROIZ. L'Eau, 16: 102–4, 1923.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Sterilization of Small Quantities of Water by Ozone. S. BRUÈRE. L'Eau. Description of Van der Made system. Two essential points are: (1) intimate mixture of ozone and water; and (2) prolonged contact: for, contrary to published statements, ozone is not instantaneous in its action. —*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Investigations on the Action of Chlorine Gas in the Continuous Purification of Swimming Pools. Techn. Gemeindeblatt, **26**: 33, 1923; Zentralbl. f. d. ges hygiene, **5**: 151, 1923; Bull. mens. office internat. d'hyg. pub., **16**: 818-9, 1924. Up to 1914 eleven munic. pools in Hamburg purified water twice daily by aëration and filtration. Satisfactory from chemical, bacterial, and comfort standpoints. Water was renewed 5 times per year and amount lowered to 117 liters per bather. Fear of conjunctivitis caused a trial of Cl. Kept count under 100 bacteria per cubic centimeter and Bact. coli could not be found in 100 cc. when free Cl exceeded 0.2 p.p.m. To reduce count to less than 100 per cc. 0.5 p.p.m. applied Cl was necessary. Practically, dose was 0.65 p.p.m. Cl. After filtration water was nearly sterile. In emergency, dose may be raised to 2 to 3 p.p.m. Cl.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Bacteriophage and Auto-Purification of Water. P. C. Flu, Versl.d. Afdeel. Naturkunde, Konigl. Akad. d. Wissenschaft, Amsterdam, 1923; Zent. f. d. ges. hyg., July 25, 1923, p. 349; Bull. mens. office internat. d'hyg. publique, **16**: 518, 1924. From series of samples of water from near Leyden may be cultivated active bacteriophage for dysentery organisms of Flexner Y and Shiga-Kruse types, for B. Faecalis alkaligenes, B. proteus X19, but not for B. typhosus, B. paratyphosus A and B, B. enteriditis gaertner, B. coli, or V. cholerae. Later tests showed that important quantities of B. typhosus and V. cholerae could disappear from water free from bacteriophages. In water rich in bacteriophages against dysentery, dysentery bacilli did not die faster than other organisms. Therefore bacteriophages have little bearing on autopurification of waters. Protozoa are probably most important. —*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Proper Charge for Fire Service from Water Works Standpoint. C. E. Inman. Fire & Water Eng., **75**: 907, May 7, 1924. If water rates are sufficiently high to cover improvements as well as operating cost, it would be unfair to impose increased charge upon all in order to help maintain protection installed on private property under private control, and partly at instance of insurance companies. It is true that owner of property, whether small or large, is entitled to protection from city's water and fire departments, but that does not necessarily mean that owner of factory, irrespective of size, and of construction materials, can demand any size of service, so as to reduce insurance. When instalment of fire protection appliances becomes compulsory, water for these fixtures should be free, but until such time it is only fair and reasonable that person benefiting by automatic fire protection should be required to pay a reasonable amount therefor.—*Geo. C. Bunker.*

Cutting the Fire Danger of Oil Burner Installations. Curtis R. Welborn. Fire & Water Eng., **75**: 637, April 2, 1924. Discussion of proper installation and maintenance of domestic oil burning equipments. Information on this subject is distributed free of charge by National Board of Fire Underwriters, 76 William St., New York City. Illus.—*Geo. C. Bunker.*

Hold up Paving Until Mains Are Laid. HENRY A. VARNEY. Fire & Water Eng., 75: 683, April 9, 1924. Short discussion of methods of restoring street surfaces of various types following excavations.—*Geo. C. Bunker.*

How a Private Water Company Kept up with City's Growth. ALBERT E. LAVERY. Fire & Water Eng., 75: 692, April 9, 1924. Short history of development of Bridgeport, Conn., Hydraulic Company.—*Geo. C. Bunker.*

Recent Methods of Differentiating Lactose-Fermenting Organisms as Applied to Indian Conditions. J. CUNNINGHAM AND T. N. S. RAGHAVACHARI. Ind. J. Med. Res., 12: 75–81, 1924. Literature dealing with classification and differentiation of lactose-fermenting bacteria is reviewed and general conclusions drawn therefrom outlined. 2.1 per cent of 960 cultures of coliform bacteria from 91 samples of human feces were of the M.R.-, V.P. type. Of these, 569 were from non-vegetarian and 391 from vegetarian sources, showing 0.4 and 4.6 per cent of the M.R.-, V.P. type respectively. This type forms 0.5 per cent of lactose-fermenting organisms in bovine feces and 29.8 per cent of those in unfiltered waters of Madras Presidency. These figures are in essential agreement with those of other investigators. Bibliography of 20 references is included.—*R. E. Thompson.*

New Low Level Pumping Station for the City of Montreal. ANON. Contract Record, 38, 558–9, 1924. New electrically driven station, nearing completion, described briefly. Changing from steam to electricity will effect saving of $510,000 annually in operating costs, and reduce operating staff from 90 to 7 men. Station was designed to accomodate six 30 million gallon pumps.—*R. E. Thompson.*

NEW BOOKS

Emergency Water Supplies for Military, Agricultural, and Colonial purposes. A. BEEBY THOMPSON. Crosby, Lockwood and Sons, publishers, London, 1924, 21 shillings.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Notions d'hydrologie apliquée a l'hygiène; bacteriologie des eaux. A. GUILLERD. Libraire Ch. Beranger, Paris et Liège, 27 F. Rev. hyg., 46: 300, 1924.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)